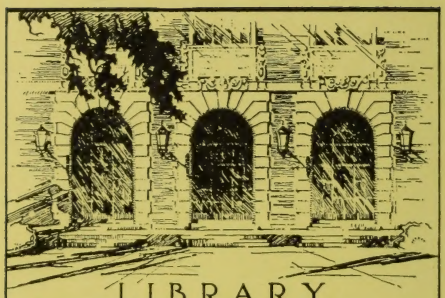

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PHYSIOLOGY OF THE TEMPERATURE OF BIRDS

By

S. Prentiss Baldwin

and

S. Charles Kendeigh

SCIENTIFIC PUBLICATIONS
OF THE
CLEVELAND MUSEUM OF NATURAL HISTORY
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TABLE OF CONTENTS

Volume III

	PAGE
Publications of the Cleveland Museum of Natural History	IV
List of Illustrations	V
List of Tables	IX
Scientific Contributions	
Physiology of the Temperature of Birds. By S. Prentiss Baldwin and S. Charles Kendeigh. (Published, October 15th, 1932)	1
Index to Volume III	175

PUBLICATIONS OF THE CLEVELAND MUSEUM OF NATURAL HISTORY

The publications of the Cleveland Museum of Natural History appear in six series, as follows:

1. *Scientific Publications,* consisting of natural history and anthropological papers of technical character, of varying length and appearing at irregular intervals.

   Of this series, all of Volume I, containing numbers 1-5, issued, 1928–1931; Volume II, issued in one number, 1931; and Volume IV, number 1, issued, 1932, have already been published. The present contribution constitutes Volume III complete.

2. *Popular Publications,* which are non-technical articles of general natural history or anthropological interest, issued also at irregular intervals.

   Of this series, numbers 1-2 of Volume I have appeared, 1928-1931.

3. *Bulletin,* containing short popular, educational, or semi-technical articles on natural history and anthropology; notes on the Museum's activities; and the Museum's announcements. It is published monthly, except in July and August.

   Of this publication, numbers 1-54 have been issued, 1922-1931.

4. *Pocket Natural Histories,* consisting of popular pocket educational manuals for the information of students in natural history and anthropology, including keys and illustrations for the ready identification of species.

   Of this series the following have been published:

   No. 1—Trees of Ohio, 1922.
   No. 2—Indian Homes, 1925.
   No. 3—Mound Builders, 1925.

5. *Annual Report,* containing the report of the Director and the reports of the different departments of the Museum, setting forth their activities during the preceding year.

   Two of these have been published, those for 1929 and 1930.

6. *Miscellaneous Publications,* comprising educational leaflets; and such other publications of local or temporary interest as descriptions of the Museum and its work, post cards, cards for games, lecture and other programs, and announcements of other Museum activities.

   A considerable number (about 100) of such publications have already appeared.

LIST OF ILLUSTRATIONS

PLATES

Physiology of the Temperature of Birds

PLATE		PAGE
Frontispiece.	Eastern House Wren (*Troglodytes aedon aedon*)	
I.	A. Types of thermocouples	6-A
	B. Recording potentiometer	
II.	A. Indicator potentiometer	22-A
	B. Sensitive galvanometer	
III.	A. Apparatus used for studying the effect of variations in air temperature on the body temperature of birds	38-A
	B. Water bath used in apparatus for studying the effect of variations in air temperature on birds	
IV.	A. Position of a thread thermocouple above the eggs in a nest of an eastern house wren	54-A
	B. Nest box of an eastern house wren with thermocouple wires and thermograph shelter.	
V.	A. Type of daily record of bird temperature obtained by a recording potentiometer	54-B
	B. Details of a portion of a daily record of body temperature of an eastern house wren	

TEXT FIGURES

Physiology of the Temperature of Birds

FIGURE		PAGE
1.	Thermoelectric circuit (thermocouple)	14
2.	Electrical connections in a recording potentiometer .	17
3.	Fluctuations in the body temperature of an eastern house wren while its standard temperature was being determined	25
4.	Fluctuations in the body temperature of eastern house wrens held in the hand	34
5.	Body temperature of an eastern chipping sparrow held in the hand; effect of food	39
6.	Effect of a high and rising air temperature on the body temperature of an eastern house wren	45
7.	Effect of a high and rising air temperature on the body temperature of an eastern house wren	46
8.	Effect of a low and falling air temperature on the body temperature of an eastern house wren	48
9.	Effect of a low and falling air temperature on the body temperature of an eastern house wren	48
10.	Rate of breathing movements in the adult eastern house wren at different body temperatures	53
11.	Typical variations in body temperature of the adult female eastern house wren while incubating . . .	65
12.	Daily variation in body temperature of birds of different species	73
13.	Average daily rhythm in body temperature of passeriform birds	79
14.	Average daily temperature rhythm of an eastern house wren	81
15.	Average daily temperature rhythm of an eastern house wren	82

FIGURE PAGE
16. Average daily temperature rhythm of an eastern house wren 82
17. Average daily temperature rhythm of an eastern robin 83
18. Average daily temperature rhythm of an eastern robin 83
19. Average daily temperature rhythm of a wood thrush . 84
20. Average daily temperature rhythm of a cedar waxwing 84
21. Average daily temperature rhythm of a catbird . . . 85
22. Average daily temperature rhythm of a catbird . . . 85
23. Average daily temperature rhythm of an eastern song sparrow 86
24. Average daily temperature rhythm of an eastern chipping sparrow 86
25. Average daily temperature rhythm of an eastern wood pewee 87
26. Reversal of daily rhythm in body temperature of an eastern chipping sparrow 92
27. Fluctuation in body temperature of a starling in anaesthesia 94
28. Development of temperature control in nestling eastern house wrens 108
29. Correlation of development of temperature control in the eastern house wren 109
30. Variation with age in the rate of breathing movements of immature eastern house wrens 115
31. Rate of breathing movements of nestling eastern house wrens at different body temperatures 116
32. Effect of high and rising air temperature on the body temperature of a nestling eastern house wren . . . 117
33. Effect of high and rising air temperature on the body temperature of a nestling eastern house wren . . . 118
34. Effect of high and rising air temperature on the body temperature of a nestling eastern house wren . . . 118
35. Effect of a fall in air temperature on the body temperature of a nestling eastern house wren 122
36. Survival time of nestling eastern house wrens at different air temperatures 125
37. Fluctuations in body temperature of a newly hatched eastern house wren in the nest 128

FIGURE PAGE

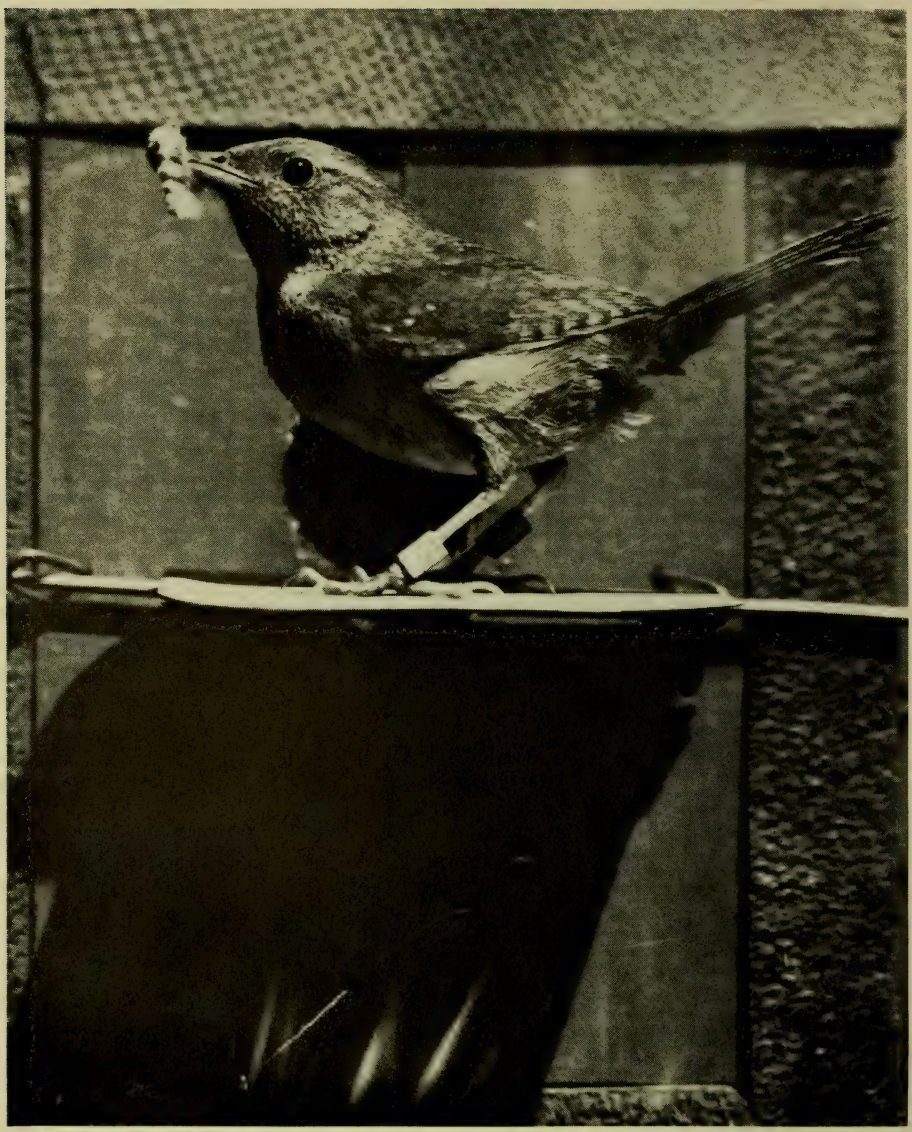
38. Development of body temperature of immature eastern house wrens in the nest 129
39. Effect of variations in air temperature on the temperature of the egg of the eastern house wren 135
40. Fluctuations in temperature of the eastern house wren's eggs in the nest 146
41. Temperature gradients in an eastern house wren's nest 153

LIST OF TABLES

Physiology of the Temperature of Birds

TABLE		PAGE
I.	Body temperature of adult birds taken with a mercury thermometer	13
II.	Influence of room temperature on accuracy of recording potentiometer	20
III.	Standard temperature	27
IV.	Variation in standard temperature with season	30
V.	Maximum body temperature of the eastern house wren	32
VI.	Maximum body temperature of other birds	33
VII.	Fall in body temperature of birds when held in the hand after capture	35
VIII.	Recovery of adult birds from low body temperature	49
IX.	Rate of respiratory movements at different body temperatures	51
X.	Skin temperature of the eastern house wren	57
XI.	Average differences in skin temperature between sexes of eastern house wren	58
XII.	Relation between the skin and internal body temperatures of the female eastern house wren at different air temperatures	60
XIII.	Periods of attentiveness and inattentiveness in various species of birds (females)	66
XIV.	Body temperature of passeriform birds, females, during the period of incubation	70
XV.	Time of daily maximum and minimum bird temperatures	88
XVI.	Daily extremes and range in temperature of female birds on the nest	89

TABLE		PAGE
XVII.	Standard temperature of immature eastern house wrens after establishment of temperature control	112
XVIII.	Effect of high and low air temperatures on the body temperature of the immature eastern house wren	119
XIX.	Survival time and loss in weight of nestling eastern house wrens when confined without food at different air temperatures	126
XX.	Relation between temperature of eggs and that of the surrounding air	137
XXI.	Effect of exposure to high air temperatures on the hatching of the eastern house wren's eggs	140
XXII.	Effect on hatching of the exposure of the eastern house wren's eggs for various lengths of time to air temperatures of 60-70° F. and relative humidities of 80% to 90%	143
XXIII.	The temperature of different parts of the nest of the eastern house wren	153



Eastern House Wren *(Troglodytes aedon aedon).*

The bird is standing on the trap-perch of its nesting box. Note the numbered aluminum band for identification around the left leg, and the colored celluloid band indicating sex around the right leg. *(Natural size.)*

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PHYSIOLOGY OF THE TEMPERATURE OF BIRDS

BY

S. PRENTISS BALDWIN AND S. CHARLES KENDEIGH

Contribution No. 21
from The Baldwin Bird Research Laboratory
Gates Mills, Ohio

CONTENTS

PAGE

INTRODUCTION 5
Historical Account 5
Acknowledgments 6
Purpose of the Study 7
Physiological Point of View 7
Ecological Point of View 8
Scientific Names of Birds Included in this Study . . . 9
METHODS OF STUDY 11
Research Facilities 11
Instruments Used 12
Mercury thermometer 12
Thermocouple 14
Recording potentiometer 16
Indicator potentiometer 21
Sensitive galvanometer 21
BODY TEMPERATURE OF ADULT BIRDS . . . 22
Standard Temperature 22
Treatment of birds before determining standard temperature 23
Behavior of birds during the experiments. 25
Standard temperature determined 26
Sex difference in standard temperature 28
Constancy of standard temperature 29
Normal Temperature 31
Effect of emotional excitement 31
Effect of muscular activity 34
Effect of food and of starvation 37
Effect of fluctuations in air temperature 42
Upper lethal body temperature 45
Lower lethal body temperature 47
Rate of Respiratory Movements at Different Body Temperatures 50
Skin Temperature 56

PAGE

Body Temperature of Birds under Natural Conditions . 61
Method 62
Average temperature of female birds on the nest during incubation 64
Fluctuation in body temperature from day to day . 72
Daily rhythm in body temperature 76
Experimental control and reversal of daily temperature rhythm 91
Mechanism of Temperature Control 94
BODY TEMPERATURE OF NESTLING BIRDS . 105
Poikilothermic (Cold-blooded) Stage in the Development of Warm-blooded Animals 105
Development of Temperature Control in Young Birds . 108
Rate of Respiratory Movements in Young Birds . . . 114
Resistance of Young Birds to High Temperature . . . 117
Resistance of Young Birds to Low Temperature . . . 121
Survival Time of Young Birds at High and Low Temperatures 124
Normal Temperature of Young Birds in the Nest . . . 127
TEMPERATURE OF EGGS AND NEST 133
Fluctuation in Egg Temperature under Experimental Conditions 134
Resistance of Embryos to High Temperature 139
Resistance of Embryos to Low Temperature 141
Fluctuation of Egg Temperature in the Nest 145
Temperature of Incubation 148
Fluctuation in Temperature of the Nest 151
SUMMARY AND CONCLUSIONS 155
BIBLIOGRAPHY 161
INDEX 175

INTRODUCTION

HISTORICAL ACCOUNT

Temperature is a factor of primary importance in both the physiology and ecology of animals. The rate at which most physiological processes function is determined largely by temperature. In fact, the maintenance of a certain degree or range of temperature within the body is essential for the proper functioning and coordination of physiological processes in most warm-blooded (homoiothermic) animals. If this temperature is not maintained, dormancy, improper functioning of organs, or even death may result. This subject of the temperature of animals long ago attracted the attention of investigators.

An extensive general account of animal temperatures is given by Edwards (1839) and this contains much on the temperature of birds. Gavarret's account, coming at a somewhat later date (1855), is excellent for those interested in following the history of this subject. Pembrey (1898) summarized most of the literature up to near the end of the 19th century, not only on mammalian and human temperatures, but also on the physiology of bird temperature. The best modern accounts of animal temperature are those of Pütter (1911), Lusk (1921), Barbour (1921), Starling (1926), and Bazett (1927). These texts, however, deal only incidentally with birds.

The chief students of the temperature of birds in the twentieth century have been Simpson (1905-1912), Hildén and Stenbäck (1916), Bergtold (1917), and Wetmore (1921), although others have done valuable work along more restricted lines. Groebbel's work (1920-1928) on the metabolism of birds is important for a satisfactory understanding of the factors influencing temperature.

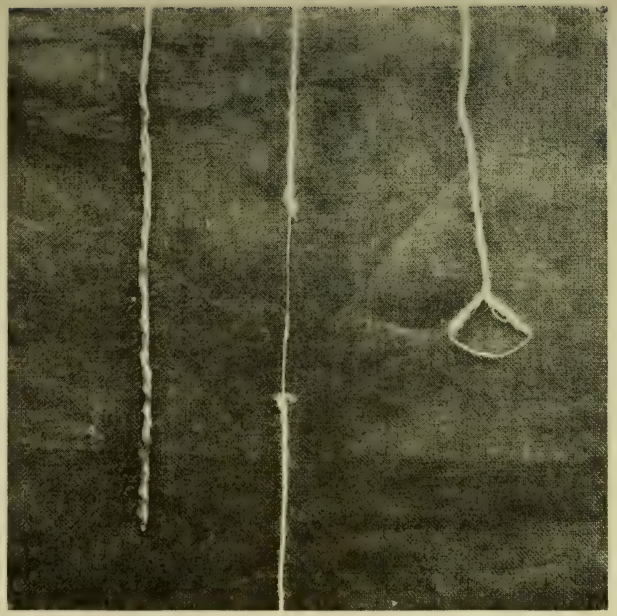
Our first work on this study of the physiology of the temperature

of birds was done in 1926. Aside from a brief description of method (Baldwin and Kendeigh, 1927), and a short report describing the development of temperature control in nestling house wrens (Kendeigh and Baldwin, 1928), we have published nothing on bird temperature up to this time (1932). The present contribution is intended to serve for a preliminary survey of the whole field and for the presentation of results thus far obtained. Final results and conclusions have not been obtained on any one phase of the general problem. Each item in the physiology of bird temperature is now ready for more detailed and analytical investigation. The survey here presented will aid in orienting and correlating such special studies in the problem of bird temperature. We have ready for publication by Kendeigh such a concentrated study on the resistance of birds to environmental cold and heat, and have started a detailed study of temperature and other factors involved in incubation.

Much is to be learned from the correlation of physiology and behavior in birds. Bird behavior is determined as much by physiological "urges" as by nervous reactions to external stimuli. In this report, stress is placed more on working out the physiological side than on correlation with behavior, although a beginning has been made in the latter. An interpretation of some of these data with respect to the abundance, migration, and distribution of birds will follow in the paper by Kendeigh to which reference has already been made.

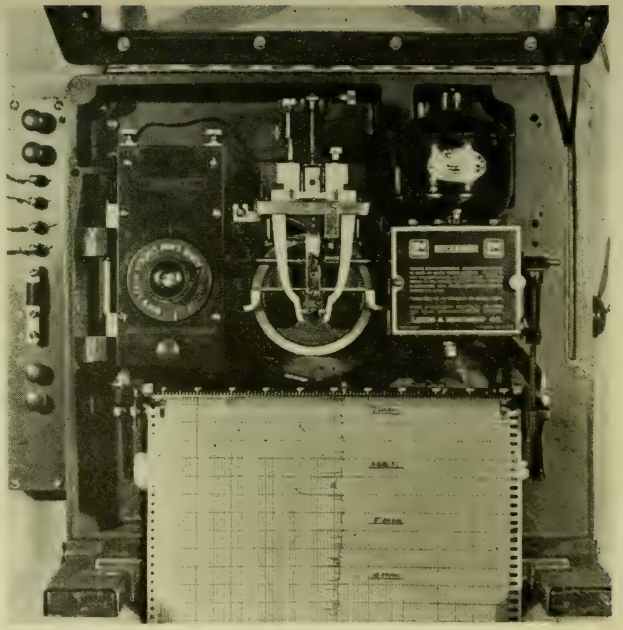
ACKNOWLEDGMENTS

Acknowledgments are due several persons who have aided more or less directly in this study. We are constantly under obligation to Dr. C. Baldwin Sawyer, president of the Brush Laboratories in Cleveland, Ohio, who has assisted by suggesting and constructing useful instruments and apparatus as well as aiding us in the mechanics of their use. The manuscript was read for criticism in whole or in part by Dr. Victor E. Shelford, Dr. Leon J. Cole, Dr. Harry C. Oberholser, and Dr. C. J. Wiggars. The following assistants at the Baldwin Bird Research Laboratory, Gates Mills, Ohio, have aided in various ways: Rudyerd Boulton, W. W. Bowen, C. H. Johnson, T. C. Kramer, James Stevenson, and L. G. Worley.



A.—Types of Thermocouples.

The one on the left is for internal body temperature (thermocouple thermometer); the one in the center is for nest temperature (thread thermocouple); and the one on the right is for skin temperature (loop thermocouple).



B.—Recording Potentiometer.

PURPOSE OF THE STUDY

Variation in body temperature may be produced both by internal and external factors. The main source of heat in the body lies in the general metabolism of the tissues and particularly of the muscles. Anything that disturbs the metabolism of the body is very likely to modify the body temperature unless proper compensation is made.

External factors may affect the temperature of the body through increasing or decreasing heat loss from the organism, and through modifying internal heat production. Low environmental temperature greatly lowers the body temperature of cold-blooded (poikilothermic) animals. In warm-blooded organisms, this depressing action is compensated for by increased heat production and decreased heat loss. Some organisms are able to adjust to changes in environmental temperature more than others, while some species withstand certain degrees of temperature which others cannot. Temperature is thus a factor in the distribution of organisms, and plays an important role in the activities of most species.

Birds have the highest constantly maintained body temperature of all animals, except for those few forms of low organization occurring in hot springs or under certain peculiar conditions in the tropics. Mammals have a lower temperature than birds, and their temperature usually varies only within comparatively narrow limits. Monotremes and hibernating mammals form exceptions to this rule. The body temperature of at least the higher species of birds is variable over a wide range. As a result of this, the influence of external and internal factors on body temperature may be profitably studied in these forms.

The purpose of the present study then is partly to learn the physiology of bird temperature, and partly to discover the relation existing between these temperatures and the environmental conditions under which the bird lives.

PHYSIOLOGICAL POINT OF VIEW

Very little is known about the physiology of bird temperature, except in a general way. This is due to the previous difficulty of obtaining living wild birds in sufficient number and variety with which to work, to the difficulty of obtaining the right sort of instru-

ments with which temperature may be properly taken, and to the easier use of mammals and man in studies of body heat and metabolism. With proper methods of capturing and handling birds, however, they offer subjects for a wide range of experimental purposes, and are of considerable value in studies of such physiological problems as temperature.

The temperature of birds was studied in this work under both laboratory and field conditions. Attempt was made to study all phases of the problem both under controlled conditions, for the purpose of analyzing the reactions more closely; and under natural conditions, where the relation between the normal behavior of the bird and natural environmental conditions could more easily be observed. One set of experiments served as a check and control for the other, and so the advantages of both methods were obtained.

Most of this study and experimentation was carried out on the Ohio subspecies of the house wren, the eastern house wren, *Troglodytes aedon aedon*.[1] Other species are considered, but no extensive comparative work was done on them. This was due partly to the limitations of equipment and time, and partly to the desire for analyzing the factors involved in the physiology of one bird as fully as possible before special effort was applied to other forms. We are reasonably sure, however, that the reactions of this species are typical of at least the large order of Passeriformes.

ECOLOGICAL POINT OF VIEW

All living organisms are affected by external conditions to a greater or less extent. To meet changes in the environmental factors which occur regularly during different seasons of the year, between different localities, and during different activities, there must be internal physiological adjustments. The physiological processes of an organism are in large part conditioned by the external environment in which it finds itself. This is true with temperature fully as much as with oxygen supply, available food and drink, and barometric pressure. It is necessary, then, when one undertakes to study the physiology of such sensitive and responsive organisms as birds, to consider the ecological conditions in which the organisms live and to interpret his findings in rela-

[1]See footnote on page 10.

tion to these conditions. The physiology of bird temperature is probably different and the bird's activities and responses to environmental conditions much changed in the tropics from what they are on the Arctic tundra, or on the deserts of the southwestern United States from what they are in the mild temperate eastern portion.

The subspecies with which we are most concerned here, the eastern house wren, *Troglodytes aedon aedon*,[2] is a seasonal member (socies) of two ecological communities in the eastern part of the United States and Canada—the Acer-Fagus (hard maple-beech) Association, and the Quercus-Castanea (oak-chestnut) Association. It remains as a constituent member in these biotic communities from the last of April to the first of October. Within these associations, the species may be found most commonly in subclimax plant and animal communities developing after fires or lumbering operations, or around human habitations. Its presence in any particular locality within these habitats is determined largely by the availability of nesting sites. During the winter season, it is found rarely in the climax Quercus-Castanea (oak-chestnut) Association, more commonly southward in the subclimax southern pine forest (Pinus Associes), and rather abundantly in Florida where it enters the magnolia-bay forest (Magnolia-Tamala Association) in the northern part of the state, and the sub-tropics in the southern part. It migrates in the spring and fall between these two areas. In its ecological relationships, this species appears to be more or less typical of a large portion of the avifauna of these ecological communities.

SCIENTIFIC NAMES OF BIRDS INCLUDED IN THIS STUDY

In the use of names we here follow the American Ornithologists' Union Check-List of North American Birds, Fourth Edition, 1931.

Eastern Bob-white, *Colinus virginianus virginianus* (Linnaeus).
Killdeer, *Oxyechus vociferus vociferus* (Linnaeus).
Eastern Mourning Dove, *Zenaidura macroura carolinensis* (Linnaeus).
Ruby-throated Hummingbird, *Archilochus colubris* (Linnaeus).

[2]See footnote on page 10.

Northern Flicker, *Colaptes auratus luteus* Bangs.
Red-bellied Woodpecker, *Centurus carolinus* (Linnaeus).
Eastern Hairy Woodpecker, *Dryobates villosus villosus* (Linnaeus).
Northern Downy Woodpecker, *Dryobates pubescens medianus* (Swainson).
Northern Crested Flycatcher, *Myiarchus crinitus boreus* Bangs.
Eastern Phoebe, *Sayornis phoebe* (Latham).
Eastern Wood Pewee, *Myiochanes virens* (Linnaeus).
Purple Martin, *Progne subis subis* (Linnaeus).
Eastern Crow, *Corvus brachyrhynchos brachyrhynchos* Brehm.
White-breasted Nuthatch, *Sitta carolinensis carolinensis* Latham.
Eastern House Wren, *Troglodytes aedon aedon* Vieillot.[3]
Catbird, *Dumetella carolinensis* (Linnaeus).
Brown Thrasher, *Toxostoma rufum* (Linnaeus).
Eastern Robin, *Turdus migratorius migratorius* Linnaeus.
Wood Thrush, *Hylocichla mustelina* (Gmelin).
Eastern Bluebird, *Sialia sialis sialis* (Linnaeus).
Cedar Waxwing, *Bombycilla cedrorum* Vieillot.
Starling, *Sturnus vulgaris vulgaris* Linnaeus.
Eastern Yellow Warbler, *Dendroica aestiva aestiva* (Gmelin).
Northern Yellow-throat, *Geothlypis trichas brachidactyla* (Swainson).
English Sparrow, *Passer domesticus domesticus* (Linnaeus).
Eastern Cowbird, *Molothrus ater ater* (Boddaert).
Eastern Cardinal, *Richmondena cardinalis cardinalis* (Linnaeus).
Red-eyed Towhee, *Pipilo erythrophthalmus erythrophthalmus* (Linnaeus).
Eastern Chipping Sparrow, *Spizella passerina passerina* (Bechstein).
Eastern Field Sparrow, *Spizella pusilla pusilla* (Wilson).
Eastern Song Sparrow, *Melospiza melodia melodia* (Wilson).

[3]The subspecific status of the Ohio house wren is at present under investigation; but pending any necessary change in name, we are following current usage in calling this bird the eastern house wren.

METHODS OF STUDY

RESEARCH FACILITIES

The Baldwin Bird Research Laboratory is the only biological laboratory either in this country or abroad that is devoted chiefly to the physiological and ecological life-history studies of wild birds. As a result, new methods of attack and new approaches to problems have had to be worked out independently.

A building of ample size, conveniently situated, and well supplied with instruments and other equipment, makes possible the carrying out of all manner of experiments with the birds available.

Around the laboratory building there is a bird sanctuary of 15 acres where approximately 125 nests are studied each season. Of these nests, about 16 belong to eastern house wrens, involving 8 to 10 pairs of birds. The proximity of the nests allows intensive study of these birds.

Numerous traps of various sorts are available in this sanctuary for capturing many species of birds. Some 2000 birds are handled in the active living condition each season. They are handled not only once but many times during the year without disturbing their normal nesting behavior in any material way. In the case of the eastern house wren, the birds are captured at their nests. All these nests are in boxes (Frontispiece; Plate IV–B) so that the bird must enter or leave through a narrow entrance hole. A trap perch on the outside of the entrance, pulled shut over the hole by a string, permits the bird to be captured in the box at will.

In addition, numerous birds for experimental use are brought in from outside this immediate area around the laboratory. These are mostly house wrens. Some 400 nest boxes have been located on various neighboring estates, and constant record is kept of all activities. About 150 adult house wrens and 800 young birds are handled each year, making available a large number of individuals

for physiological study. It is with these resources that the study of the temperature of birds is conducted.

The modern methods of bird banding originated at this laboratory (Baldwin, 1919). This is mentioned because the exact and continuous identification of the individual bird furnishes the basis for this study as well as all lines of research at the laboratory. Each bird is identified by a numbered aluminum band placed around its leg. The bands are issued by the Bureau of Biological Survey, Washington, D. C., and all work is done under permit issued by the Biological Survey.

INSTRUMENTS USED

Mercury thermometer.—Thermometers at first, and thermocouples later, were used in this investigation. The thermometer has been the standard instrument in clinical diagnosis since the days of Boerhaave, 1668–1738. It has been and is still being used in much physiological work. Wetmore (1921) used the thermometer entirely in his study of bird temperature.

All the mercury thermometers used at this laboratory were especially adapted and constructed for our purposes. They were fashioned after the ordinary clinical thermometer commonly used by physicians. However, they differ from the clinical thermometer in registering temperatures from 90° to 115° F., instead of to 110° F. only. The thermometers are self-registering like the clinical type, but their diameters are smaller and their bulbs in some cases are longer.

After experimenting with readings down the throat, through the anal opening, under the wing, and on the belly, it has been found that the most accurate method of obtaining the bird's temperature is to thrust the thermometer down the throat of the bird until it has penetrated well down next to the body cavity, which means usually that the bulb is down the gullet as far as the proventriculus. It is then left several seconds until the mercury ceases to rise, when it is removed and read. All the thermometers have a certified accuracy of one-tenth of a degree, Fahrenheit scale. In this way several temperatures were taken of different species of birds. Table I illustrates the type of results that is obtained by this method.

TABLE I.—*Body Temperature of Adult Birds Taken with a Mercury Thermometer*

Species	Sex	Number of Records	Average Body Temperature
Eastern bob-white	Male	1	111.2° F. (44.0° C.)
Eastern mourning dove	?	4	108.8° F. (42.7° C.)
Ruby-throated hummingbird	Female	1	108.0° F. (42.2° C.)
Red-bellied woodpecker	Female	1	109.8° F. (43.2° C.)
Northern downy woodpecker	Male	1	108.1° F. (42.3° C.)
" " "	Female	2	108.4° F. (42.4° C.)
Northern flicker	Male	1	109.2° F. (42.9° C.)
" "	Female	1	107.5° F. (42.0° C.)
Eastern phoebe	Male	1	110.0° F. (43.3° C.)
" "	Female	1	110.9° F. (43.8° C.)
Northern crested flycatcher	Female	2	111.4° F. (44.1° C.)
Purple martin	Male	1	108.2° F. (42.3° C.)
" "	Female	1	110.4° F. (43.6° C.)
Eastern yellow warbler	Male	1	108.0° F. (42.2° C.)
" " "	Female	1	110.2° F. (43.4° C.)
Eastern crow	Male	1	106.0° F. (41.1° C.)
Eastern bluebird	Male	1	107.1° F. (41.7° C.)
" "	Female	2	110.0° F. (43.3° C.)
Eastern robin	Male	3	109.6° F. (43.1° C.)
" "	Female	2	109.5° F. (43.1° C.)
Catbird	?	1	108.4° F. (42.4° C.)
Eastern house wren	Male	18	108.6° F. (42.6° C.)
" " "	Female	21	108.2° F. (42.3° C.)

These records have a certain amount of value since they give an approximate idea of what the temperature of the bird may be at any one instant. However, as will be shown later, the temperature of birds, at least in the higher Passeriformes, is exceedingly variable, and these variations cannot well be followed by this type of thermometer. No one temperature observation is of great significance. After any one reading is taken the thermometer must be removed and the mercury shaken down before a new reading can be taken. As the bird is usually excited and agitated when first captured and handled, the temperature, if taken at once, will not have the same significance as when the bird has later become quiet and at ease. Also, as we have shown in a previous paper (Kendeigh and Baldwin, 1928), the thrusting of a cold thermometer into a young bird may cause an appreciable lowering of its body temperature, even to several tenths of a degree. Later additional determinations on juvenal English sparrows verify this

effect even to the extent of four-tenths or five-tenths of a degree Fahrenheit. This depressing effect on body temperature was determined by taking first a reading of the body temperature by means of a thermocouple (Plate I–A) thrust through the anal opening into the rectum, then inserting the mercury thermometer down the throat, and then taking another reading of the body temperature with the thermocouple in the rectum. The two readings of the thermocouple could then be compared with that of the mercury thermometer. Due to these disadvantages and to the fact that another and better method of obtaining temperatures was developed, the use of the thermometer, in this study, was discarded at the end of the second season's work. Aside from one or two phases of the work, all this study is based on records obtained by the use of the thermocouple. Using thermocouples, the bird's temperature may be followed continuously over almost indefinite lengths of time.

Thermocouple.—According to Kimball (1917), knowledge of the principle of thermoelectricity dates back to 1821, when Seebeck, of Berlin, discovered that "in a circuit made of two different metals if one junction is hotter than the other there is an electromotive force which causes an electric current." Thus if two different

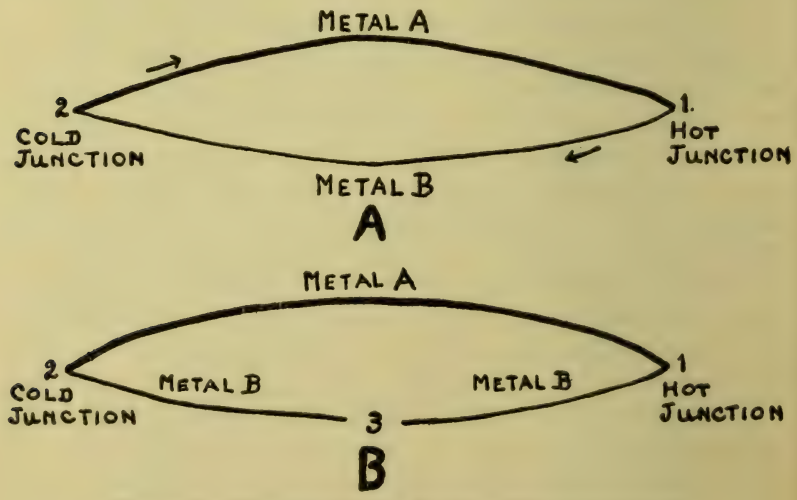


FIGURE 1.—THERMOELECTRIC CIRCUIT (THERMOCOUPLE).

metals, designated A and B above (Figure 1–A), be joined together at points 1 and 2, and point 1 heated to a temperature higher than point 2, a current will flow around the circuit. The direction of the current depends on the character of the metals used. If the thermoelectric circuit be broken at any point, as at point 3 in the diagram (Figure 1–B), the current, of course, will cease flowing, and a difference of potential or electromotive force will appear.

The magnitude of this electromotive force depends on the temperature difference between points 1 and 2, and furnishes a means of measuring this temperature difference. If one of the junctions, for example the cold junction at point 2, be maintained at a constant temperature, the temperature at point 1 is determined when the electromotive force is known. This, in brief, is the principle and basic nature of the thermocouple.

Becquerel and Breschet in 1838 appear to have been the first to make serious use of the thermocouple in physiological work. Using thermocouples of copper and steel they investigated the temperature of the mouth and certain of the tissues and internal organs of the body in man and some of the lower animals. The history of the use of thermocouples has been reviewed by Gamgee (1908) and Karrer and Estabrook (1930). Thermocouples are now being used rather generally by physiologists.

We first used thermocouples and a recording potentiometer to obtain continuous day and night records of bird activities at the nest (Baldwin and Kendeigh, 1927), but we have since developed the instrument to do accurate temperature work.

All the thermocouples that we have used have been made of copper and constantan (an alloy of copper and nickel). All the wires are silk insulated, and the warm junction is made by soldering together the ends of the two metals.

The thermocouple junction may be prepared in various ways, dependent on the purpose to be served (Plate I–A). For obtaining internal body temperatures the wires back of the junction are twisted around each other so that a *thermocouple thermometer* is formed. The wires are well insulated except at the soldered tip, so this is the only point effective in taking temperatures, since it is the only point where the two metals are in contact. To insure further protection and insulation, a coating of collodion is given the wires for three or four inches back of the junction; this, when

dried, forms a firm, flexible, waterproof covering. For obtaining body temperatures, this thermometer is thrust down the gullet of the bird so that the junction is usually as far as the proventriculus. It was found that unless the junction were inserted this far a difference of two or three degrees would result, since the temperature of the upper neck and mouth is lower than that of the body proper. There was no evidence from the results obtained or from the actions of the bird that, except in a few unusual cases, there was any local congestion or irritation as the result of the presence of the thermocouple. In fact, at times, the birds actually went to sleep with the thermocouple two or three inches down their throats. The thermocouple could be left in the bird as long as desired and numerous readings taken.

For obtaining skin temperatures a modification of the thermocouple thermometer is used. In this, a loop is left just back of the junction before the wires are twisted around each other. This permits the junction to lie flat on the skin and to be thrust up underneath the feathers. Also, collodion is not used to coat these wires. This we call our *loop thermocouple* (Plate I–A).

The *thread thermocouple* (Plate I–A) is best for getting nest temperatures. This is made simply by soldering the tips of the two metals to each other and not twisting them together. The thermocouple can then be stretched either above or below the eggs as a continuous thread or wire extending from one side of the nest to the other.

Recording potentiometer.—Owing to the small magnitude of the electromotive forces involved in the use of thermocouples (generally less than .002 volt in the work to be described), only the most delicate and sensitive instruments can be employed for their measurement. We have used both recording and indicator instruments. When a continuous record of temperature variations is to be made, the recording instrument must be designed not only for great sensitiveness, but also for strength enough to make the record. The Leeds and Northrup Company have developed such a recorder (Plate I–B). Their instrument is operated in conjunction with a thermocouple composed of the two metals, copper and constantan. The two thermocouple wires are run directly to the recorder, which is therefore at the same temperature as the cold

junction. An electrically compensating device, embodied in the instrument, automatically corrects for external temperature variations at the recorder and gives as true an indication of temperature at the warm junction, as though the cold junction were maintained constant at zero.

The recorder operates on the potentiometer system, by which a small sensitive galvanometer needle is caused to swing to the right or left whenever the warm junction is at a temperature higher or lower than that indicated on the recorder (Figure 2). At once,

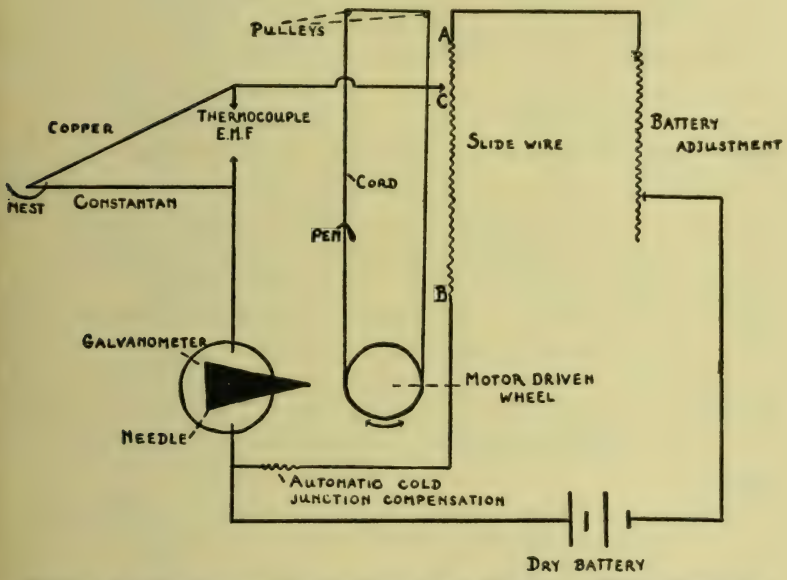


FIGURE 2.—ELECTRICAL CONNECTIONS IN A RECORDING POTENTIOMETER.

through the agency of levers, cams, etc., a small electric motor causes a wheel, attached by a cord to the recording pen, to rotate one way or the other until the temperature indicated by the recorder is again the same as that at the warm junction. At this point the galvanometer needle is again in its neutral position and the recording pen is at rest.

When at rest, the electromotive force of the thermocouple is exactly balanced with a potential produced by two dry cells. The potential of the dry cell current is greater at A than at B and passes

gradually from the first extreme to the second because of the increasing resistance in the slide wire. Thus by varying the location of point C, through the revolving of the wheel mentioned in the paragraph above, any thermocouple potential may be balanced against an equal potential in the dry cell circuit. The two potentials are of opposite polarity, and so oppose each other. Hence, when the two potentials are equal, no current flows around the thermocouple and a uniform temperature record is produced. When the thermocouple potential becomes greater or less than the potential of the dry cell circuit at point C, a current flows around the thermocouple until C is shifted to a point between A and B which will make the two potentials again equal.

The recording pen attached to the cord bears on a paper rolled past at a constant speed by means of the same small motor above mentioned. Thus there is furnished a paper and ink record of temperature variations with the time of each. This paper is marked in degrees of temperature, and the instrument can be adjusted to use either the Centigrade or Fahrenheit scale. We have given some thought to the question of which scale should be used for the temperature studies in our laboratory, and finally decided to use Fahrenheit, because it is in more general use in America, particularly by physicians, is better understood by most people, and its unit of measurement is smaller. However, in all the tables and figures given in this paper, the Centigrade equivalents are included in parenthesis immediately after the Fahrenheit temperatures.

The operation of the recorder requires a small amount of power from the electric light circuit and also the daily standardization of the current from the dry cells. The recorder is placed in the laboratory, and wires are run out to any nest near at hand. The warm junction end of the thermocouple is placed in the nest. The thermocouple wire at this point is thin and flexible, and is run from one side of the nest box through the nest just above the eggs (if it is eggs that happen to be in the nest) and then out on the other side (Plate IV–A). The junction of the two metals, copper and constantan, comes at the middle of the nest.

When the adult bird enters the box and settles down on the eggs, she, of course, applies heat to them and warms up the nest cavity. The increase in temperature causes an increase of electric potential

at the recorder, and this is registered on the paper evolving from the recorder in the laboratory by a variation in the line drawn by the pen. Every time that the bird settles down in the nest there will be one kind of variation in the line, and every time that she leaves the nest there will be another kind of variation—because of the difference in the temperature of the nest. In fact, every time she stirs around in the nest to any extent, shifts her feet, gets up on the rim of the nest, or goes to the entrance of the box for an instant, the movement will be registered by characteristic marks in the record (Plate V). Since the recorder is in action day and night we have thus a fairly complete record of the activities of the adult bird at the nest. It is possible to get such records of the female from the beginning of the nest-building activities until the end of the brooding period.

The manufacturers guarantee an absolute accuracy of 0.5% of the temperature range of their instrument, which variation in the case of the recording potentiometers would be ± 1.0° F. (0.6° C.). The instruments were checked and calibrated at frequent intervals during the work by means of a standard thermometer. It was not unusual even after several days of continuous running for the recording instruments and the standard thermometer to read exactly alike. At other times the recorder would be a half degree or so too high or too low, never more. The recorder would be then corrected, and the error allowed for in the records obtained. Special care was taken to have the recording instrument read accurately between 100° F. (37.8° C.) and 112° F. (44.4° C.).

The long thermocouple wires (200 feet) used to connect the recording instrument to the nest caused no error in the readings of the potentiometer. These were checked against short thermocouple wires of about 4 feet in length, and identical temperatures were recorded.

The recording potentiometers are equipped, as already stated, with an automatic cold junction compensation coil which is supposed to compensate for all variations in room temperature where the instrument is placed, so that the cold junction is maintained constant. Extensive tests have been carried out to check this compensation.

The recording instrument was connected with a thermocouple placed in a water bath in a thermos bottle maintained at constant

temperature. A standard thermometer was inserted into this thermos bottle, and the thermocouple wound around it so that the water temperature that the thermocouple was reading could be accurately determined. The recording instrument, placed in another room, was then subjected to air temperature changes of various degrees and varying rapidity of fluctuation. The temperatures recorded by the instrument at these different room temperatures were then compared with those obtained by means of the standard thermometer, with the results shown in Table II.

TABLE II.—*Influence of Room Temperature on Accuracy of Recording Potentiometer*

Degrees Change in Room Temperature	Number of Tests	Error in Record Made by Recording Potentiometer
Drop of 20°–30° F. (11.2°–16.8° C.)	5	+1.0° F. (0.6° C.)
Drop of 10°–20° F. (5.6°–11.2° C.)	5	+0.6° F. (0.3° C.)
Drop of 1°–10° F. (0.6°–5.6° C.)	4	0.0
Rise of 1°–10° F. (0.6°–5.6° C.)	5	0.0
Rise of 10°–20° F. (5.6°–11.2° C.)	6	—0.5° F. (0.3° C.)
Rise of 20°–30° F. (11.2°–16.8° C.)	5	—1.0° F. (0.6° C.)

These tests show that the recording instrument does not register absolutely the same at all room temperatures, but when the air temperature is low it registers high, and when the air temperature is high it registers low. For medium variations in room temperature, however, this error is negligible; that is, for fluctuations in room temperature of 10° F. (5.6° C.) or even 20° F. (11.2° C.) in either direction.

With this possible source of error in mind, special care was taken always to keep the recording instruments at temperatures as nearly constant as possible. This could be done rather easily by keeping them in basement rooms. Record kept of the daily variation of temperature in these rooms assured us that there was no appreciable error from this source, since in no case did the room temperature vary more than a very few degrees, while the extreme variation reached during the entire period of study was only 12° F. (6.7° C.), and this lasted for only a short time.

Frequent and varied testings of these recording instruments

assure us, therefore, that the accuracy of ± 1.0° F. (0.6° C.) guaranteed by the manufacturers was obtained. Actually, however, since hundreds and in some cases thousands of records are averaged to obtain the figures quoted below, the plus and minus errors in recording tend to cancel each other and thus produce results that have an accuracy considerably greater than ± 1.0° F. (0.6° C.).

Indicator potentiometer.—The indicator potentiometer (Plate II–A) is based on exactly the same principles as the recording instrument except that it does not give a continuous automatic and permanent record. Each temperature must be read by eye from the scale. To compensate for this disadvantage the instrument is smaller, less cumbersome, readily portable, and more sensitive to changes in temperature at the warm junction of the thermocouple. For ordinary use, this instrument has a guaranteed accuracy of 0.45° F. (0.25° C.), but to make it even more accurate, a larger and more sensitive galvanometer than that which ordinarily comes with the instrument was used in this work. This increased the dependable accuracy of the records to one-tenth or two-tenths of a degree (F.) at ordinary room temperatures. The automatic cold-junction compensation for differences in room temperature is not perfect, and so a correction must be applied when the instrument is used at widely different air temperatures.

Sensitive galvanometer.—Still another instrument (Leeds and Northrup Company) was used in obtaining the temperature of eggs (Plate II–B). This consists of a galvanometer with reflecting mirror, scale, and telescope. Slight variations in the galvanometer are read through the microscope directed at the mirror which in turn reflects the scale. Two thermocouples were used; one placed in a thermos bottle with a standard thermometer, the other subjected to the temperature to be measured. Differences in potential between the two thermocouples were measured on the scale and calibrated into degrees of temperature. This, when added or subtracted from the reading of the standard thermometer, gave the temperature measured. This was our most accurate instrument for measuring temperatures, being accurate to better than 0.1° F., or with some further adjustments to a few hundredths of a degree.

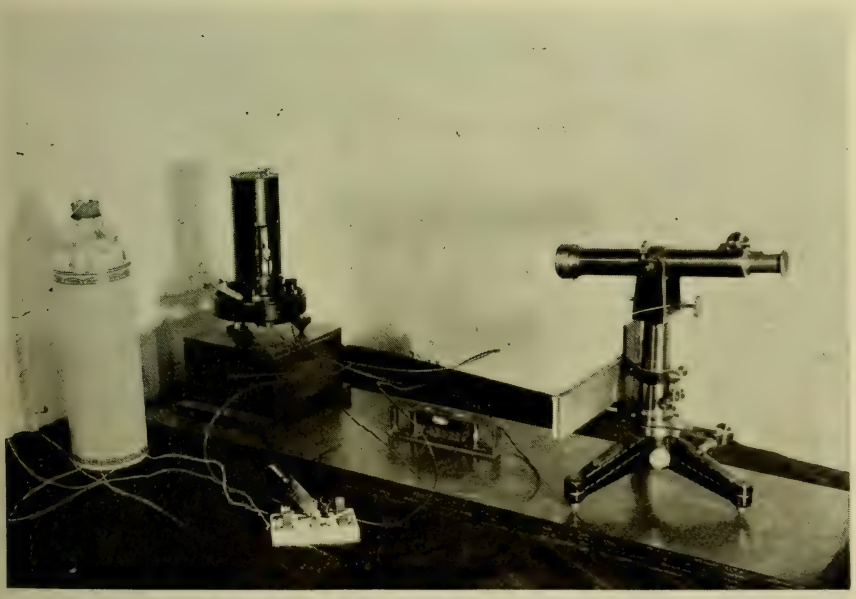
BODY TEMPERATURE OF ADULT BIRDS

It seems in the past generally to have been assumed that birds have a definite and constant temperature. Only recently has it been pointed out that the body temperature of birds is subject to considerable fluctuation (Stoner, 1926; Kendeigh and Baldwin, 1928). Previous investigators, using mercury thermometers, have assumed that the readings obtained were characteristic. Care was not even taken, in many instances, to keep the bird quiet while the readings were made, so that muscular activities and excitement have caused inaccurate results. Sea birds were formerly caught for such purposes with baited hooks and lines. Some more recent investigators (Simpson, 1912–a; Wetmore, 1921) have taken the temperature of birds immediately after killing them. With the smaller active passeriform species, variations in the temperature of single adult individuals of as much as ten degrees are not unusual at different hours of the day. This is more variation than previous observers have obtained between many different species of birds, and is more than the averages obtained between such widely separated groups as *Apteryx* (100.2° F. [37.9° C.], Sutherland, 1899) and Turdidae (108.9° F. [42.7° C.], Wetmore, 1921). According to Simpson and Galbraith (1905), there is less temperature variation in large birds than in the smaller species. Such great fluctuations as occur in the house wren may not be typical for all birds; but, from some comparative work, we believe that they occur to some such extent in the great order Passeriformes, which makes up by far the larger part of our common land avifauna.

STANDARD TEMPERATURE

In spite of the general variability in the temperature of birds under normal living conditions, there is one temperature, the *standard temperature,* which is much more constant and which can be determined by experiment. That temperature is the temperature of standard or basal metabolism. The standard metabolism of an organism is its metabolism or energy exchange when at com-

A.—Indicator Potentiometer (Portable).



B.—Sensitive Galvanometer (Portable).

plete rest and at a sufficient time after the last meal to escape the stimulating effect of food (Krogh, 1916). Standard metabolism has been very generally confused with basal metabolism, but as Krogh points out the two are not strictly synonymous. Certain functional activities still operate even when the organism is at rest, such as the heart beat, respiratory movements, glandular action, muscle tone, etc., and these may account for a large percentage of the total standard metabolism and production of body heat. If these factors could be eliminated or corrected for, then basal metabolism would be determined, but as yet it has not been generally practicable to do this.

In this study no direct correlation of standard metabolism and standard temperature has been made. The temperature obtained has been assumed to be that of standard metabolism because it was obtained under conditions identical with those obtaining for standard metabolism. To determine the standard temperature of the birds, they were captured, taken to the laboratory, kept without food for a while, and their temperature taken while at complete rest.

Treatment of birds before determining standard temperature.—As most of the work of obtaining standard temperature was done with the eastern house wren, it will be considered first and the other species will be taken up later for comparison. All the house wrens used were captured at their nest boxes after they had entered to feed the young or to incubate the eggs. This was usually after a period of inattentiveness to nest duties when they had been absent from the box for a few minutes getting and ingesting food themselves. So at time of capture their stomachs were usually filled with recently obtained food.

The birds were removed from the box by means of a small gathering net placed over the entrance hole. This net is made of black mosquito netting sewed around a wire frame. The birds were driven out of the box into this net where they were easily taken in hand. If caught near the laboratory they were carried there immediately. If caught at one of the outlying boxes they were placed in darkened cages and brought to the laboratory later.

In the laboratory, the birds were first confined in small cages covered with one or two layers of black cloth so that they were in

the dark. This was necessary in order to keep them quiet. Also, from the time of capture until release they were without food. From other experiments, we have evidence that 2.5 hours is sufficient time for all the food in the stomach to pass through the entire length of the alimentary tract and be voided. In all cases, therefore, it could be made certain that the birds were in a post-absorptive state before attempts at determining the standard temperature were made.

Special care had to be taken not to let the birds become too weak from lack of food, yet to keep them confined in the dark long enough to quiet them sufficiently. In some instances, the birds became too weak from lack of food, and in other cases the birds could not be quieted to complete rest, so that, in all, standard temperatures could be determined on only 65% of the birds obtained for this purpose. The average length of time that the birds, both male and female, were held without food before the standard temperature was determined was 4.7 hours. Of this time, 2.6 hours were spent in darkness.

After the birds had been allowed to remain in the darkened cages the allotted length of time, they were removed and held in the left hand of the investigator. A thermocouple thermometer was thrust down the throat well into the alimentary canal, and then the bird, still in the hand, was placed in another small, narrow, dark cage. The bird was thus removed from the dark where it had been at rest, and after a minute or two returned to the dark. It was necessary, whenever it was desired to keep the birds quiet, to put them in the dark, as they were continually active in the light. Complete darkness has an almost instantaneous effect in quieting some birds. The thermocouple wires ran out of the cage from the bird to the indicator potentiometer. This was manipulated and the records of temperature and time recorded with the free right hand.

The position of the bird in the left hand was a natural one. The bird's neck was held between the first and second fingers and its feet usually rested on the third. It was only at these points that the hand came into constant contact with the bird, although frequently the side of the bird was touching the palm of the hand and at other times the thumb was used to prevent excessive struggling by the bird.

There has been suggested the possibility that being in contact with another being, and a human being at that, may have some emotional effect upon the bird which would detract from the results. Actual experiments, however, do not justify this criticism. For a check, a few birds, mostly eastern chipping sparrows, were fastened by other means in the darkened cage, and their temperatures taken. The records obtained in this less convenient and less satisfactory manner were quite comparable with those obtained from the bird held in the hand. The warmth of the hand could not well affect the bird because of the insulating coat of feathers. As the bird was held loosely, free circulation of air around the bird was not appreciably handicapped.

Behavior of birds during the experiments.—Ordinarily the birds while in the darkened cage remained quiet or moved around only to a very limited extent. When the bird was removed for the insertion of the thermocouple, it had to be taken into the light for a minute or two, and this always caused the bird to become somewhat excited and active. It was, therefore, necessary to work

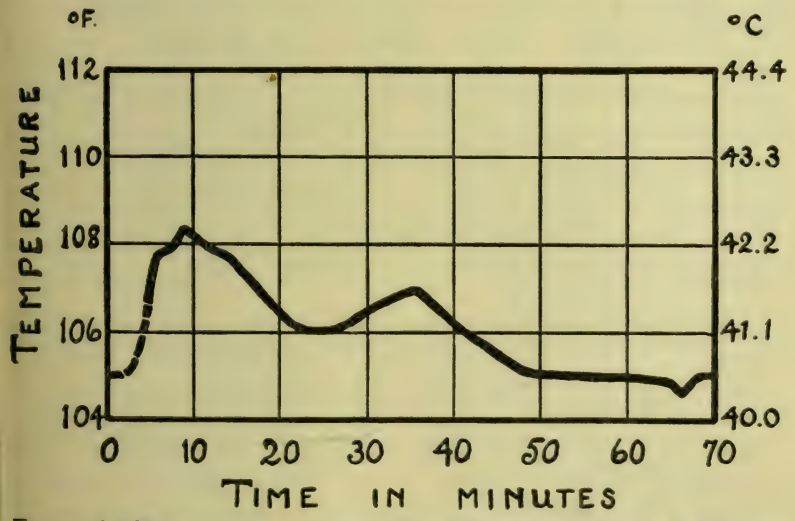


FIGURE 3.—FLUCTUATIONS IN THE BODY TEMPERATURE OF AN EASTERN HOUSE WREN WHILE ITS STANDARD TEMPERATURE (105° F. [40.6° C.]) WAS BEING DETERMINED. The temperature of the bird during the first few minutes before the thermocouple was inserted is interpolated and is shown by the broken line.

awhile with the bird in the hand when placed again in the dark before it became quiet the second time. This required on the average about 1.5 hours, although a few birds became quiet in half that length of time, and others required considerably longer. Nothing was done to pacify the birds except to hold them loosely in the hand in the dark, with external noises and commotion largely eliminated, and to prevent any excess body movements.

Figure 3 shows a typical temperature curve of a bird during the taking of a standard temperature. The first part is interpolated and represents the bird quiet in the dark cage with its body temperature at standard level. When removed from the cage for insertion of the thermocouple its temperature rises a few degrees, but when returned to the dark it begins to drop. The temperature drops until the low standard temperature level is again reached, and here it is maintained constant for several minutes. Usually it is possible to tell when the bird has reached this point, even without taking its temperature, by the feel of the bird in the hand. It is completely relaxed, absolutely motionless except for the movements caused by respiration and heart beat, its eyelids are closed, and the bird is undoubtedly as much asleep as it ever becomes. On the average, this complete relaxation was maintained for 10.2 minutes before a slight stirring or movement would cause its temperature and metabolism to increase again. In one instance it was maintained for 22 minutes, but this is unusual, even under natural conditions, with such active birds as the house wren. Another satisfactory criterion on the time when standard metabolism was attained was furnished by the rate of respiration which then reached a low steady uniform rate (pages 50–55).

Standard temperature determined.—In Table III there is given the standard temperature as determined on 31 birds of 5 species. The readings were taken with the indicator potentiometer.

It will be noticed that the standard temperatures for all 5 species lie within a few tenths of a degree of each other. The average of the 3 passeriform species (which excludes the woodpeckers), considering the figure for each species and sex of equal value, is 104.7° F. (40.4° C.). The number of records and species are too few to allow this figure to be considered the average of the order, but the probabilities are that, if such an average could be

TABLE III.—*Standard Temperature*

Band Number	Date (1928)	Time of Day	Standard Temperature	Duration
Eastern House Wren				
Male				
45546	June 12	1:30 P. M.	103.7° F. (39.8° C.)	11 minutes
45546	June 12	4:50 P. M.	103.7° F. (39.8° C.)	11 "
93573	June 15	4:20 P. M.	104.5° F. (40.3° C.)	12 "
664601	June 16	1:10 P. M.	105.0° F. (40.6° C.)	9 "
93433	June 17	3:25 P. M.	104.6° F. (40.3° C.)	16 "
35362	June 29	3:20 P. M.	104.3° F. (40.2° C.)	12 "
35363	June 30	2:05 P. M.	104.4° F. (40.2° C.)	5 "
664716	June 30	3:00 P. M.	104.4° F. (40.2° C.)	18 "
38398	July 19	1:30 P. M.	104.2° F. (40.1° C.)	12 "
93546	July 21	1:21 P. M.	104.2° F. (40.1° C.)	4 "
45320	August 1	12:50 P. M.	104.4° F. (40.2° C.)	14 "
		Average	104. 37° F. (40.2° C.)	11.3 minutes
		Probable error	±.07° F. (.04° C.)	
Female				
664708	June 17	5:05 P. M.	105.0° F. (40.6° C.)	5 minutes
45708	June 21	7:12 P. M.	105.0° F. (40.6° C.)	22 "
45350	June 22	1:10 P. M.	105.0° F. (40.6° C.)	11 "
45649	June 26	2:25 P. M.	105.0° F. (40.6° C.)	7 "
45536	June 30	11:35 P. M.	105.4° F. (40.8° C.)	15 "
45569	July 9	2:43 P. M.	104.7° F. (40.4° C.)	5 "
45348	July 26	3:35 P. M.	105.4° F. (40.8° C.)	2 "
664751	August 17	4:50 P. M.	104.9° F. (40.5° C.)	3 "
		Average	105.05° F. (40.6° C.)	8.8 minutes
		Probable error	±.05° F. (.03° C.)	
Eastern Chipping Sparrow				
Male				
45300	June 13	4:00 P. M.	105.1° F. (40.6° C.)	10 minutes
45305	June 13	5:05 P. M.	104.7° F. (40.4° C.)	10 "
45309	June 25	11:00 A. M.	104.5° F. (40.3° C.)	19 "
31900	July 14	2:00 A. M.	105.0° F. (40.6° C.)	53 "
56207	August 2	4:45 P. M.	104.9° F. (40.5° C.)	33 "
		Average	104.84° F. (40.5° C.)	25 minutes
		Probable error	±.07° F. (.04° C.)	
Female				
45314	June 9	11:30 A. M.	104.5° F. (40.3° C.)	16 minutes
38469	June 23	5:30 P. M.	105.4° F. (40.8° C.)	5 "
45315	June 27	11:30 A. M.	105.0° F. (40.6° C.)	23 "
93414	July 5	5:00 P. M.	104.8° F. (40.4° C.)	48 "
		Average	104.92° F. (40.5° C.)	23 minutes
		Probable error	±.11° F. (.06° C.)	
Eastern Robin				
Male				
549420	June 6	2:40 P. M.	104.5° F. (40.3° C.)	6 minutes
Female				
549425	June 20	7:35 P. M.	104.6° F. (40.3° C.)	6 "
Northern Downy Woodpecker				
Male				
572414	June 11	8:30 P. M.	104.3° F. (40.2° C.)	19 minutes
Eastern Hairy Woodpecker				
Female				
459740	June 3	7:45 A. M.	105.0° F. (40.6° C.)	5 minutes

obtained, it would not be far from this. Attention is called to the work of Benedict and Fox (1927), who obtained what were probably standard temperatures in many cases on several species of large wild birds under aviary conditions. The body temperatures that they obtained vary from 102.0° F. (38.9° C.) to 106.9° F. (41.6° C.), the average being 104.4° F. (40.2° C.).

Sex difference in standard temperature.—A difference between the two sexes in their standard temperatures is apparent from the above records. This difference amounts to 0.6° F. (0.4° C.), with the larger value for the female in the case of the house wren. This difference is a significant one, since it amounts to ten times the probable error. In the case of the eastern chipping sparrow and eastern robin, there is a tendency for the female to have a slightly higher temperature than the male, but the difference between the two sexes is so small that it is insignificant and within the limits of chance variation. The eastern chipping sparrow was found to be a rather difficult species with which to work, since it was not very resistant under controlled conditions and the mortality rate was greater than in any other species on which we have experimented. Possibly this greater frailty and more delicate vitality of the species was a factor in not permitting a possible difference between the two sexes to show more than it did. The single records for each sex in the eastern robin are insufficient for any serious consideration. The striking dissimilarity, however, between the two sexes in the house wren does warrant attention.

This difference between the sexes in the breeding season may possibly not persist throughout the year. Due to the functional and organic changes (Riddle and coworkers, 1925, 1927, 1928) that take place during the period of reproduction, direct comparison with other times of the year cannot be safely assumed. The reason for this discrepancy between the sexes is not clear, but appears to be bound in some way to the temperature regulating mechanism. In the ring dove, the male has been found to have a higher standard metabolism than the female (Riddle, Christman, and Benedict, 1930); and a higher metabolism has also been found in the mourning dove (Riddle, Smith, and Benedict, 1932). If this is true for the house wren also, then the rate of heat loss must be greater in the male to explain the lower body temperature.

Other observers (Martins, 1858; Simpson and Galbraith, 1905; Simpson, 1912–a) have also noted a difference in the temperature of the two sexes, with the female having the higher value, although one might question the reliability of the data with which they worked, as they were, in many cases, obviously not those of standard temperature. To Wetmore (1921) it appeared that in different groups of birds the difference in temperatures between the sexes favored the male in some cases, the female in others, while in many there was none. He attempts to correlate a higher temperature with the sex that does the major share of the duties pertaining to incubation and care of the young. In some instances his records appear to be those of standard temperature, but in the majority they are not. Where records are not those of standard temperature, any sex difference is largely obscured, at least in the higher species, by the normal variations in temperature under stress of internal and external factors, such as excitement, food, activity, etc., and any difference obtained represents more the influence of these factors on the two sexes than of any fundamental differences in metabolism. In the house wren, the higher standard temperature of the female is correlated with a slightly larger size of the body, as determined by length and breadth measurements of the thorax and abdomen, a greater total weight, and with a larger share in the nesting duties involved in reproduction.

Constancy of standard temperature.—Very little in a definite way can be said concerning the variation in the standard temperature at different hours of the day and night, as the records are not numerous enough or evenly enough distributed. Data of a little different character to be discussed in a later section (page 69) indicate that the standard temperature may be somewhat lower at night than during the day.

There is no appreciable variation in the standard temperature of either the eastern house wren or eastern chipping sparrow during the three summer months of June, July, and August (Table IV). What may occur during the winter cannot, of course, be predicted from the data available.

The average air temperature at which all the experiments with the house wren were performed was 73.8° F. (23.2° C.). Although there was some variation from this between the limits of

TABLE IV.—*Variation in Standard Temperature with Season*

Species	Sex	June		July		August	
		Number of Records	Average Standard Temperature	Number of Records	Average Standard Temperature	Number of Records	Average Standard Temperature
Eastern house wren...	Male	7	104.4° F. (40.2° C.)	2	104.2° F. (40.1° C.)	1	104.4° F. (40.2° C.)
" " " ...	Female	5	105.1° F. (40.6° C.)	2	105.1° F. (40.7° C.)	1	104.9° F. (40.5° C.)
Eastern chipping sparrow	Male	3	104.8° F. (40.4° C.)	1	105.0° F. (40.6° C.)	1	104.9° F. (40.5° C.)
" "	Female	3	105.0° F. (40.6° C.)	1	104.8° F. (40.4° C.)	..	.....
	Average		104.8° F. (40.4° C.)		104.7° F. (40.4° C.)		

62.0° F. (16.7° C.) and 83.0° F. (28.3° C.) at which the standard temperatures were determined on different individuals, no definite correlation with air temperature can be stated.

From the above discussion it appears that the standard temperature is a value of some constancy in the physiology of bird temperatures, at least during the daytime. It thus furnishes a base from which the effect of various factors on body temperature may be determined.

NORMAL TEMPERATURE

By normal temperature is meant the actual temperature of the bird during the day and night. This is most typical while the bird is carrying on normal activities under natural conditions, but is difficult to obtain, since the taking of temperature usually interferes more or less with the natural course of events or the physiological behavior of the bird. Ordinarily the bird in nature does not stay quiet for a time long enough to allow its temperature to drop to the level of standard metabolism, and, therefore, the bird seldom comes down to standard temperature except at night. Action temperatures or temperatures of birds that are excited or frightened are included in this category of normal temperatures. Some of the different factors that affect the normal temperatures of birds will first be considered, then the temperature of birds under natural conditions.

Effect of emotional excitement.—One of the chief problems that students of bird temperatures have always had to face has been to get the temperature of the bird when it is as little excited as possible. Some investigators have attempted to do this by killing the bird as nearly instantaneously as possible while it was quiet, and then taking its temperature immediately after it was shot (Simpson, 1912–a; Wetmore, 1921). In taking the temperature of living birds, the objection has been that they are so excitable that the temperature of rest could not be obtained, because fear and excitement would cause the body temperature to rise. This, however, is not the case, as the following section on the effect of muscular activity upon the body temperature will clearly bring out. The temperature of the bird falls while it is held in the hand rather than rises, and, after a few minutes, rest temperatures may be obtained.

It is true that when house wrens are first captured at the nest or taken from the traps and their temperatures determined at once, high values are obtained because of the intense excitement and struggling at capture. This is indicated in the results shown in Table V.

TABLE V.—*Maximum Body Temperature of the Eastern House Wren*

Obtained with mercury thermometer			
Male		Female	
Band Number	Temperature	Band Number	Temperature
63824	110.0° F. (43.3° C.)	34269	111.2° F. (44.0° C.)
38388	111.1° F. (44.0° C.)	34271	110.0° F. (43.3° C.)
38389	111.1° F. (44.0° C.)	63757	110.0° F. (43.4° C.)
38390	110.4° F. (43.6° C.)	38387	110.1° F. (43.4° C.)
38394	111.3° F. (44.1° C.)	38418	110.4° F. (43.6° C.)
Average	110.8° F. (43.8° C.)	.....	110.5° F. (43.6° C.)
Obtained with thermocouple			
93573	110.6° F. (43.7° C.)	45349	112.0° F. (44.4° C.)
93433	110.4° F. (43.6° C.)	45350	110.7° F. (43.7° C.)
45320	111.5° F. (44.2° C.)	45536	111.5° F. (44.2° C.)
94249	111.2° F. (44.0° C.)	664751	111.6° F. (44.2° C.)
		C68978	112.0° F. (44.4° C.)
		F45745	112.3° F. (44.6° C.)
Average	110.9° F. (43.8° C.)	.....	111.7° F. (44.3° C.)

The maximum temperature of other species is worthy of note. Records obtained from both mercury thermometers and thermocouples are here averaged together (Table VI).

The general average of the maxima of body temperatures for these various species, including the eastern house wren but excluding the two woodpeckers, which are non-passeriform species, is 111.5° F. (44.2° C.). The values for the two sexes are averaged to get a figure to represent those species in the few instances where records for both sexes are available. The highest normal record obtained from birds in the hand was 113.5° F. (45.3° C.), from a female eastern robin. The next highest record of 112.7° F.

TABLE VI.—*Maximum Body Temperature of Birds Other than House Wren*

Species	Sex	Number of Records from Different Individuals	Temperature
Eastern chipping sparrow.....	Male	5	111.3° F. (44.1° C.)
" " "	Female	1	112.7° F. (44.8° C.)
Eastern song sparrow.....	Female	1	111.8° F. (44.3° C.)
English sparrow.....	Male	1	111.1° F. (44.0° C.)
" "	Female	1	112.1° F. (44.5° C.)
Eastern robin.....	Male	3	111.1° F. (44.0° C.)
" "	Female	6	111.8° F. (44.3° C.)
Eastern bluebird.....	Female	1	111.3° F. (44.1° C.)
Eastern yellow warbler.....	Female	1	111.6° F. (44.2° C.)
Purple martin.....	Female	1	110.4° F. (43.6° C.)
Eastern phoebe.....	Female	1	110.9° F. (43.8° C.)
Northern crested flycatcher...	Female	2	112.6° F. (44.8° C.)
Northern downy woodpecker..	Female	1	110.0° F. (43.3° C.)
Northern flicker.....	Male	1	111.2° F. (44.0° C.)

(44.8° C.) was obtained from a female crested flycatcher and a female eastern chipping sparrow. A record of 112.6° F. (44.8° C.) was obtained once from another female eastern robin. In the eastern house wren, 112.3° F. (44.6° C.) has been the highest obtained, again from a female. There is evidence all through the records obtained from passeriform species that higher temperatures occur in the females than in the males. This is true with the standard temperatures, and these maximum temperatures furnish another instance. In Table VI this is apparent in the case of those species where records for both sexes are given. Where but one sex is recorded, it is in all but one instance the female. This does not always mean that no records were obtained for the male, but that they were so much lower that it was questionable that the maximum temperature of the individuals really was determined, and they were, therefore, omitted. These data, together with those on standard temperatures, would argue either that the whole level of metabolism in the female is slightly higher than that of the male during the season of reproduction, or that there is some difference in the temperature regulation.

Thus far, we have in this discussion attributed these high temperatures in birds to their excitability. This is true only in a broad sense when muscular, functional, and nervous activity are not

closely distinguished. There is some question whether or not mental excitement or emotional states in themselves cause a fluctuation in the temperature of birds. In the functional activity of nervous tissue, it has only comparatively recently been demonstrated that heat of metabolism is given off (Downing, Gerard, and Hill, 1926). This metabolism would probably not be enough to affect body temperature, although Gesell (1925) presents some evidence that the metabolism of nervous tissue may be greater than formerly supposed.

Effect of muscular activity.—Muscular activity is closely bound up with nervous and mental activity. The nervousness and excitability of birds, when first captured, are expressed in flutterings and struggles to escape. Maximum temperatures are the result of these exertions plus the previous activities of the birds before capture.

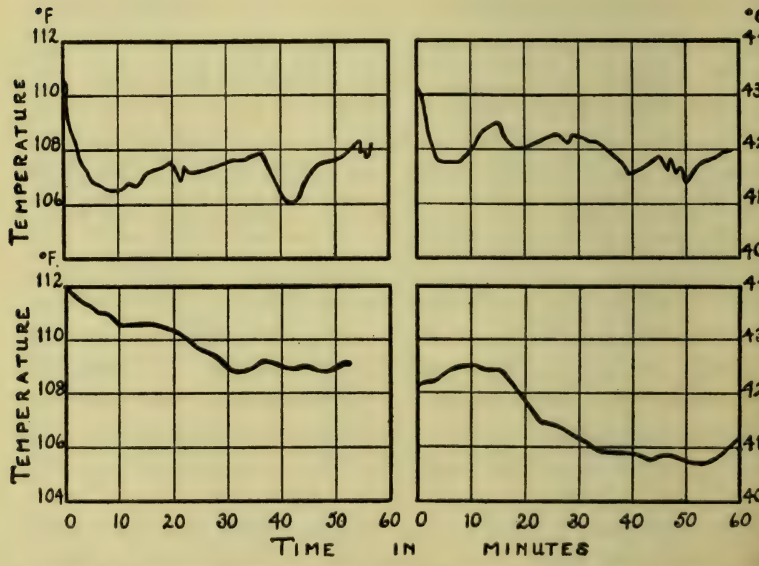


FIGURE 4.—FLUCTUATIONS IN THE BODY TEMPERATURE OF EASTERN HOUSE WRENS HELD IN THE HAND. In three instances, the unusually high initial temperatures are due to the activity of the birds after having just been captured; in the fourth, where the initial temperature is low, the bird had been kept quiet in a darkened cage several minutes before its temperature was taken.

Curiously enough, and quite opposite to what one might at first expect, the temperature of the bird after it is taken from the traps and held in the hand, or in other confinement, drops rather than rises (Table VII). The highest record one gets of the bird's temperature is usually the one first made. This drop may amount to only a few tenths of a degree (F.) over a period of several minutes, or again the drop may be as much as 4 degrees in 6 minutes or 3 degrees in 4 minutes (Figure 4). At times this fall in temperature may be more or less continuous for 30 minutes. The extent and rapidity of this drop depend in part upon the circumstances of the bird's capture, its activity before

TABLE VII.—*Fall in Body Temperature of Birds when Held in the Hand after Capture*

Species	Sex	Initial Temperature	Temperature after 10 Minutes	Temperature after 20 Minutes
Eastern house wren	Male	108.3° F. (42.4° C.)	105.5° F. (40.8° C.)	104.6° F. (40.3° C.)
"	Male	107.6° F. (42.0° C.)	108.7° F. (42.6° C.)	108.4° F. (42.4° C.)
"	Male	110.0° F. (43.3° C.)	110.5° F. (43.6° C.)	110.3° F. (43.5° C.)
"	Male	110.4° F. (43.6° C.)	109.7° F. (43.2° C.)	109.9° F. (43.3° C.)
"	Male	111.5° F. (44.2° C.)	110.4° F. (43.6° C.)	110.6° F. (43.7° C.)
"	Male	111.2° F. (44.0° C.)	110.3° F. (43.5° C.)	109.1° F. (42.8° C.)
"	Male	110.7° F. (43.7° C.)	108.8° F. (42.7° C.)	106.0° F. (41.1° C.)
"	Female	112.0° F. (44.4° C.)	111.5° F. (44.2° C.)	111.1° F. (44.0° C.)
"	Female	110.5° F. (43.6° C.)	110.2° F. (43.4° C.)	109.3° F. (43.0° C.)
"	Female	110.8° F. (43.8° C.)	110.4° F. (43.6° C.)	110.2° F. (43.4° C.)
"	Female	110.5° F. (43.6° C.)	110.1° F. (43.4° C.)	.....
"	Female	111.0° F. (43.9° C.)	109.9° F. (43.3° C.)	.....
"	Female	109.9° F (43.3° C.)	109.8° F. (43.2° C.)	109.7° F. (43.2° C.)
"	Female	111.6° F. (44.3° C.)	111.0° F. (43.9° C.)	110.8° F. (43.8° C.)
"	Female	108.8° F. (42.7° C.)	110.4° F. (43.6° C.)	.....
"	Female	111.7° F. (44.3° C.)	111.7° F. (44.3° C.)	.....
Average of 16 birds		110.4° F. (43.6° C.)	109.9° F. (43.3° C.)	109.2° F. (42.9° C.)
Eastern robin...	Male	110.2° F. (43.4° C.)	109.3° F. (43.0° C.)	107.6° F. (42.0° C.)
" " ...	Male	111.0° F. (43.9° C.)	110.7° F. (43.7° C.)	.....
" " ...	Female	111.6° F. (44.2° C.)	108.5° F. (42.5° C.)	.....
Eastern chipping sparrow	Male	111.9° F. (44.4° C.)	110.5° F. (43.5° C.)	110.3° F. (43.5° C.)
"	Female	112.7° F. (44.8° C.)	112.5° F. (44.7° C.)	108.6° F. (42.6° C.)
"	Female	108.2° F. (42.3° C.)	107.7° F. (42.1° C.)	.....
Eastern song sparrow	Female	111.8° F. (44.3° C.)	108.3° F. (42.4° C.)	106.4° F. (41.3° C.)
White-breasted nuthatch	Male	109.5° F. (43.1° C.)	108.9° F. (42.7° C.)	.....
Eastern crow....	Male	106.7° F. (41.5° C.)	105.7° F. (41.0° C.)	.....
Northern downy woodpecker	Male	109.5° F. (43.1° C.)	108.3° F. (42.4° C.)	106.7° F. (41.5° C.)
Eastern hairy woodpecker	Female	109.0° F. (42.8° C.)	107.0° F. (41.7° C.)	.....

TABLE VII (Continued).—*Fall in Body Temperature of Birds when Held in the Hand after Capture*

Species	Sex	Temperature After 30 Minutes	Temperature After 60 Minutes
Eastern house wren	Male	104.6° F. (40.3° C.)	103.7° F. (39.8° C.)
" " "	Male	108.1° F. (42.3° C.)	107.9° F. (42.2° C.)
" " "	Male	109.2° F. (42.9° C.)	106.9° F. (41.6° C.)
" " "	Male	.....	.....
" " "	Male	110.6° F. (43.7° C.)	110.0° F. (43.3° C.)
" " "	Male	107.2° F. (41.8° C.)	.....
" " "	Male	105.3° F. (40.7° C.)	.....
" " "	Female	110.5° F. (43.6° C.)	.....
" " "	Female	108.3° F. (42.4° C.)	.....
" " "	Female	109.7° F. (43.2° C.)	109.3° F. (43.0° C.)
" " "	Female	.....	.....
" " "	Female	.....	.....
" " "	Female	109.6° F. (43.1° C.)	109.4° F. (43.0° C.)
" " "	Female	.....	.....
" " "	Female	.....	.....
" " "	Female	.....	.....
Average of 16 birds		108.3° F. (42.4° C.)	107.8° F. (42.1° C.)
Eastern robin	Male	106.7° F. (42.0° C.)	.....
" "	Male	.....	.....
" "	Female	.....	.....
Eastern chipping sparrow	Male	108.9° F. (42.7° C.)	.....
" " "	Female	108.7° F. (42.6° C.)	.....
" " "	Female	.....	.....
Eastern song sparrow	Female	105.2° F. (40.8° C.)	.....
White-breasted nuthatch	Male	.....	.....
Eastern crow	Male	.....	.....
Northern downy woodpecker	Male	105.7° F. (41.0° C.)	104.2° F. (40.1° C.)
Eastern hairy woodpecker	Female	.....	.....

capture, the food it has taken, its struggling in the hand, and the degree to which it may be quieted. Ordinarily the drop becomes less apparent after a few minutes. After this, the bird's temperature fluctuates to a greater or less degree (Figure 4). This is true in all species studied. Gradually the temperature sinks, however, and the fluctuations keep dropping lower and lower until after some hours the standard temperature is reached. Stoner (1928) took the temperature of house wrens at one minute intervals with a clinical thermometer and also found that it dropped from 110.6° F. (43.7° C.) to 105.8° F. (41.0° C.). Activity then raised the temperature from 105.8° F. (41.0° C.) to 106.5° F. (41.4° C.).

If the bird has been at rest, there is at first obtained a temperature of a medium degree rather than the maximum. Then, as the

bird strives to escape, its temperature may rise by reason of the muscular activity brought into play. After the excitement wears off, the temperature again drops (Figure 4).

In all cases the birds eventually become quieted in the hand, and all movement ceases except for occasional slight struggles. Muscular activity is generally recognized as one of the most important factors in the production of heat in the body. Hence when muscular activity ceases, heat production is decreased, and the body temperature drops.

The effect of muscular exercise is even more apparent when the body temperature drops to the standard level. This is well shown in Figure 1. Here even the slightest movements cause a rise of temperature. The stimulating effect which food has is absent in this case, so that the rise in temperature is clearly due to muscular activity alone. This effect of activity in wild birds is in harmony with the rise in temperature of man which has been observed as a result of work (Pembrey, 1898; Benedict and Snell, 1902), and also in the domestic fowl (Féré, 1899).

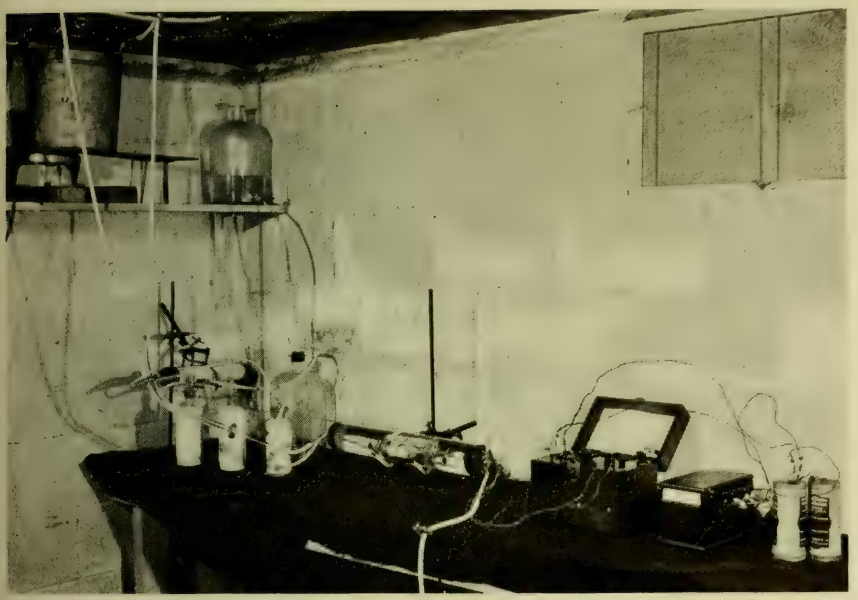
Effect of food and of starvation.—Ever since the time of Lavoisier and Sequin, 1789 (Benedict and Carpenter, 1918, page 10), it has been known that the ingestion of food causes an increase of metabolism in animals. According to Rubner, proteins, carbohydrates, and fats each have a specific dynamic action, stimulating heat production in the cells of the body. From the experiments of Benedict and Carpenter (1918), it appears that the proteins have more effect than any other nutrient in increasing metabolism in man, and that it makes little difference whether the protein is of animal or plant origin. Carbohydrates of various kinds and fats have striking influences upon the metabolism, but the increases produced are less. Lusk (1921) discussed in detail the role of nutrition in the metabolism of animals. According to Groebbels (1928–a) the specific dynamic action of food has the effect of increasing the oxygen intake 20%–30% in doves. It is of interest in this connection that the food of the eastern house wren is largely insects, and so proteinaceous. Hence the food eaten must be one factor in maintaining the metabolism at the high level that it attains. A higher rate of metabolism implies of necessity a greater heat production. A larger or smaller part of

the increased heat production caused through absorption of food may be lost through increased heat dissipation.

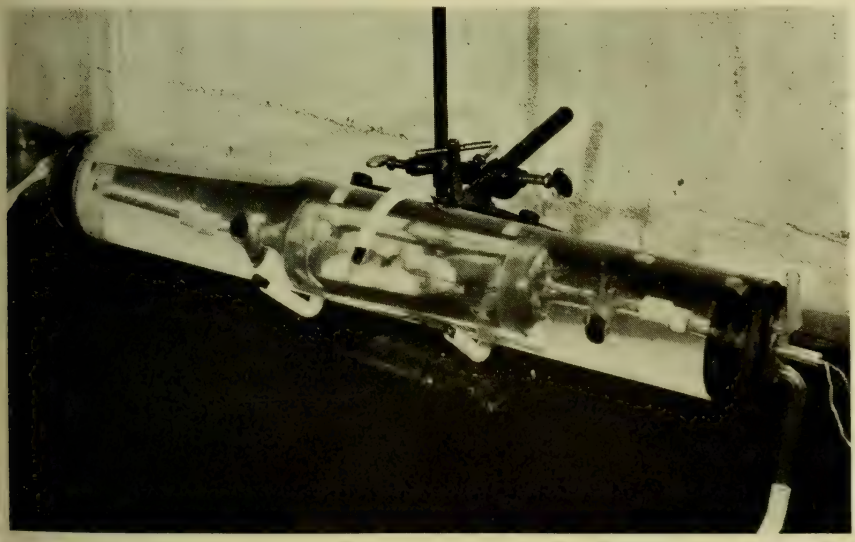
With all the birds used for the determination of standard temperature, time had to be allowed not only for the birds to attain the greatest muscular repose but also to attain a post-absorptive state as regards food. If this were not done, the standard temperature could not be attained, even when the bird was limited in its activity. Benedict and Riddle (1929), in the case of ring doves and common pigeons, noted a progressive decrease in the respiratory quotient during the first 24 hours, this indicating a change from a predominantly carbohydrate metabolism to one of predominantly fats or possibly proteins. The latter condition of standard metabolism is apparently attained in less than 5 hours in the house wren, probably because digestion is completed more rapidly.

In Table VII we have already noted that during the first hour when bird temperatures were taken continuously by means of thermocouples down their throats, their body temperature was gradually falling. This fall in body temperature is a fluctuating one marked by short periods of rising and falling temperature, dependent primarily on the activity of the bird. This tendency for a gradual fall in temperature continues for 4 to 5 hours in the case of the house wren, until standard metabolic or essentially fasting conditions are reached. It is only then that the constant standard temperature may be obtained. This fall in body temperature is apparently due, in addition to cessation from exercise, to the difference in the metabolism of the bird occasioned by this change from an active feeding and absorptive condition to one of fasting. External air temperature is not a factor here, since in our experiments it was fairly uniform, and, as will be shown later, it does not, anyway, appreciably affect the body temperature. The nutritional state of the bird is an important consideration, therefore, in determining the body temperature.

Experiments were performed with individual birds which were confined in a small cage, alternately with food and without food for periods of time, and their temperature then taken. All this work was done with eastern song sparrows and eastern chipping sparrows, since they feed more freely in captivity than do strictly insectivorous species. In determining the effect of a lack of food



A.—Apparatus Used for Studying the Effect of Variations in Air Temperature on the Body Temperature of Adult Birds, Immature Birds, and Eggs.



B.—Water Bath Used in Apparatus for Studying the Effect of Variations in Air Temperature on Birds. Note the inner air chamber containing eggs, the thermocouples inserted into this chamber through the air exit tube, and the water bath that surrounds the air chamber.

on bird temperature, a sufficient time must be allowed for the species to get into a post-absorptive condition. In the case of the sparrows this must be at least 2.5 hours, preferably longer.

A few experiments yielded significant results, as indicated in Figure 5. In these cases, the natural body food reserve was

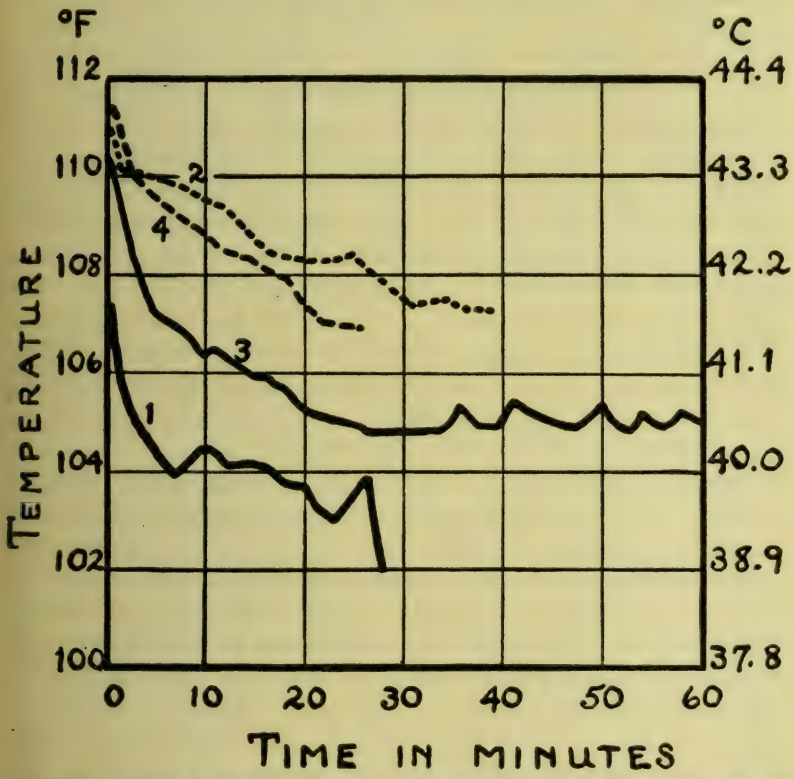


FIGURE 5.—BODY TEMPERATURE OF AN EASTERN CHIPPING SPARROW HELD IN THE HAND. Lines 1 and 3 are after periods when the bird had been deprived of food; 2 and 4 after periods when the bird had freely consumed food for some time. High initial temperature is result of struggle during insertion of the thermocouple.

probably reduced before the experiments began, due to several days' confinement, so that the bird was unusually sensitive to the presence or absence of the stimulating effect of food.

An average of the initial temperatures at each period of observation gives for the intervals when the bird had all the food it

desired, 111.1° F. (44.0° C.), and for the intervals when it was deprived of food for about 2.5 hours, 108.9° F. (42.7° C.). These two figures, however, include also the effect of muscular exertion concomitant with the removal from the cage and insertion of a thermocouple down its throat. At the end of 25 minutes, when the bird had become relatively quiet, the average of the two records of the bird with food is 107.7° F. (42.1° C), while without food it is 104.2° F. (40.1° C.). It is thus clear that the ingestion of food into the body is associated with a rise in the bird's temperature, and that, along with muscular activity, it must be considered a factor in maintaining the bird's body temperature.

When a bird is deprived of food for a prolonged time, actual starvation or under-nutrition occurs. This is concomitant with a marked decrease in heat production. With ring doves, Benedict and Riddle (1929) found a decrease from 3934 calories per 150 grams of body weight, which was the rate 24 hours after the birds had been deprived of food, to 3343 calories after 48 hours. With such a marked decrease in heat production, it is reasonable to expect a lowered body temperature in starved birds, and this is what actually occurs.

The most extensive work that we have found in the literature relating to the effect of starvation on the body temperature of birds is that by Chossat in 1843. His work was principally with pigeons and doves which he kept without food till they either died or were at the point of death. The general conclusion that he reached in regard to the effect of starvation on body temperature may be summarized in the following quotation (page 309): "Il résulte là que *l'inanitiation* a pour effet d'accroître progressivement l'oscillation diurne de la chaleur jusqu'à ce que le refroidissement devienne assez grand pour que la réaction diurne ascensionnelle ne s'opère plus, ou presque plus, et que l'animal périsse prochainement de froid." He believed that lack of food caused a break of the temperature control mechanism, and that death was due actually to the low body temperatures reached rather than to any other cause. Our own work confirms the drop in body temperature observed by Chossat, as do also a few experiments by Groebbels (1928–b).

In the case of the eastern house wren, when the air temperature is medium, the most pronounced effect of lack of food begins to

be felt at about the seventh hour. The temperature falls beneath the level of standard metabolism, and apparently the whole general metabolism of the bird becomes depressed. This is very apparent in the behavior and appearance of the bird, for it becomes very listless, inactive, and weak, and the breathing becomes marked. The bird tends to maintain one position consistently, eyes closed, and the feathers raised and ruffled all over the body. The head is lowered and the bird becomes unresponsive to outside stimuli. It may be picked up and placed on its side, where it will remain. The body temperature continues to drop, until finally, with a general contraction of the muscles all over the body and a shivering, the bird dies. This final general contracting of the muscles is sufficient to raise the body temperature in eastern chipping sparrows from one-tenth to three-tenths of a degree. Some birds die quietly without showing this slight rise in temperature. Seven birds have died from the effects of lack of food while under observation. The temperatures of two eastern house wrens at that time were 94.0° F. (34.4° C.) and 87.5° F. (30.8° C.); of three eastern chipping sparrows, 98.6° F. (37.0° C.), 96.6° F. (35.9° C.), and 87.4° F. (30.8° C.); and two English sparrows, 89.1° F. (31.2° C.) and 84.8° F. (29.3° C.). Death in the smaller passeriform birds from lack of food and at ordinary air temperatures occurs within a very few hours.

We are not willing to agree, in entirety, with Chossat that death of birds from starvation is due merely to the breaking down of the temperature control mechanism. In experiments to be described later in another connection, the body temperature of adult house wrens has been lowered to even below 75° F. (23.9° C.) before they had a chance to become starved, yet the birds lived when their temperature rose again as a result of artificial heating. Death from starvation in our birds occurred at body temperatures from 84.8° F. (29.3° C.) to 98.6° F. (35.9° C.). The cause of death in birds long deprived of food seems to be, therefore, some defect caused by under-nourishment and not directly the low body temperature reached, although if this low body temperature is long maintained, it is undoubtedly important. Lusk (1921) discusses certain theories as to the cause of death by starvation in mammals including man, but leaves the question unsettled.

In summarizing the importance of food to passeriform birds,

it is evident that the metabolism of food is important for maintaining the body temperature. When birds are subjected to prolonged starvation, there is a lowering of body temperature below that which is normal, and death eventually occurs. This gives evidence for the belief that under natural wild conditions birds must have continual access to an abundant food supply; and if for any reason this is not forthcoming, death will follow.

Groebbels (1928–a) would classify all birds in two main categories according to their sensitiveness to food supply. His first class would be characterized by a good chemical heat regulation, fewer requirements in the way of food, greater resistance to hunger, greater sluggishness in movement, lower body temperature, and lower metabolism. His second class would be characterized by a higher body temperature which could be maintained only with an abundance of food and great activity, and would be further characterized by a high rate of digestion, less resistance to hunger, and greater rate of metabolism. All the birds considered in this text would fall into his second class, as undoubtedly would most passeriform species.

Effect of fluctuations in air temperature.—The possible effect of high and low air temperatures on the body temperature of animals has been the subject of investigation by scientists for a good many years. Edwards (1839) discusses the subject and sums up the previous literature. He believed that he found a seasonal variation in the temperature of sparrows. Pembrey (1898) summarizes the discussion up to nearly the end of the century. Sutherland (1899) states that birds perish when their temperature reaches 113° F. (45.0° C.). This figure is commonly seen in discussions concerning the upper thermal death point of animals. More recently, Wetmore (1921) finds that moderate fluctuations in air temperature are not constantly correlated with variations in the body temperature of most birds as long as they are able to obtain sufficient food and maintain their vitality. Rowan (1925) kept juncos successfully under artificial conditions out of doors all through a severe winter, by supplying them with plenty of food.

In our study, some attention was paid to the experimental determination of the limits in body temperature that birds can resist.

These variations in body temperature were induced comparatively rapidly by changing the air temperature to which the birds were subjected. Special apparatus had to be arranged for this, the details of which are well enough brought out in the accompanying photographs (Plate III) to render extensive description unnecessary. The bird was placed in an inner glass chamber through which a constant rapid flow of air was forced by water pressure, or, later, by water suction. Around this inner chamber, water was run in a larger glass tubing. By varying the temperature of the water introduced into this outer chamber, either by heating it on an electric hot plate or cooling it with ice, a wide range of temperature in the air of the inner bird chamber could be obtained practically at will, and, with some attention, could be maintained as long as desired; or the change from one temperature to another could be made either rapidly or slowly. The bird's body temperature was obtained by means of a thermocouple down its throat. The temperature of the air just before it reached the bird was determined by means of another thermocouple. The records were read on the indicator potentiometer, and an accuracy of about one-tenth of a degree was obtained. The rate of ventilation of air through the bird chamber averaged more than 100 cc. per minute.

It was not possible, during the short period available for these experiments, to develop a method of controlling and varying the relative humidity of the air to determine what effect this may have on the thermal resistance and regulation in birds. However, the humidities that occurred were measured by means of wet and dry bulb thermometers placed well into the bird chamber. At air temperatures from about 70° F. (21.1° C.) down, the air was nearly saturated, probably varying from 90% to 100% relative humidity. Hence, the lower thermal limits for birds were determined under these conditions. It is to be remembered that during the breeding season of these birds, the minimum air temperature for the day out-of-doors almost always come at night and that at this time the normal humidity is usually over 90%, so the conditions under experimental control actually approximated the natural conditions in this respect to which the birds are normally subjected. When this same air was heated to 115° F. (46.1° C.) the relative humidity would be considerably decreased. Reference to the psychrometric chart prepared by the Carrier Engineering Company indi-

cates that the humidity would be about 30%. Thus the humidity approximated natural conditions out-of-doors during the hottest time of day. There is no evidence to indicate that the wide differences in relative humidity in these experiments had any effect on the body temperature of the birds.

Controls were obtained in each experiment by keeping the bird in the tube under room temperature and the proper ventilation for several minutes before any variations in the air temperature were produced. The bird's temperature was taken during this period and determined as normal before the experiment was begun. In later work, an electric refrigerator was used for obtaining the low air temperatures desired, and the birds placed inside this.

Experiments were performed on more than 55 individuals of 13 species, although only in the eastern house wren were the upper and lower limits of tolerance for body temperature approximately determined. The average length of the experiments was less than 2 hours. All the birds were used as soon as possible after capture, and so any depression of metabolism and body temperature as a result of lack of food was avoided. Muscular activity on the part of the bird was eliminated except for minor twitching and struggling, as the bird was placed in a loose-fitting, large-meshed bag made of mosquito-netting, to which the thermocouple was attached. Typical graphs showing the results obtained are given in Figures 6, 7, 8, and 9.

From these studies, it was evident that small variations in air temperature, when they are within the limits to which the birds are accustomed, have no effect on the body temperature. A variation of 2 or 3 degrees in body temperature, particularly if it is a decrease in temperature from an initial high figure, would normally be expected to occur in the bird's temperature regardless of external air temperature, due to cessation of muscular activities, and so allowance must be made for this. For instance, in Figure 8, a drop of 13 degrees in the air temperature from 73° F. (22.8° C.) to about 60° F. (15.6° C.) corresponds to a drop in the bird's temperature from 109.0° F. (42.8° C.) to 107.0° F. (41.7° C.), but this drop would probably have occurred even were the air temperature maintained constant. However, in another instance (Figure 7), the air temperature was increased from 71° F. (22.8° C.) rapidly at first, then more gradually to 96.5° F. (35.8° C.). This

rise of 25.5° F. (14.3° C.) in 37 minutes produced an increase in the bird's temperature over a similar period of 3.0° F. (1.7° C.). These particular cases are typical of others. Thus it seems that moderate fluctuations in the normal air temperature have little or no effect on the bird's temperature, although large fluctuations occurring within a short time may produce some temporary variation.

Upper lethal body temperature.—After showing experimentally that moderate fluctuations in air temperature have practically no effect on the body temperature of the house wren, a study was next made of the upper and lower limits of body temperature that the bird could withstand. Four records are available in regard to the upper lethal body temperature in the house wren. The same apparatus was used as was described in the preceding section. The bird's body temperature was caused to rise by raising the air temperature rather rapidly to a high degree.

On several occasions, the body temperature of different species of birds between 112.0° F. (44.4° C.) and 113.5° F. (45.3° C.)

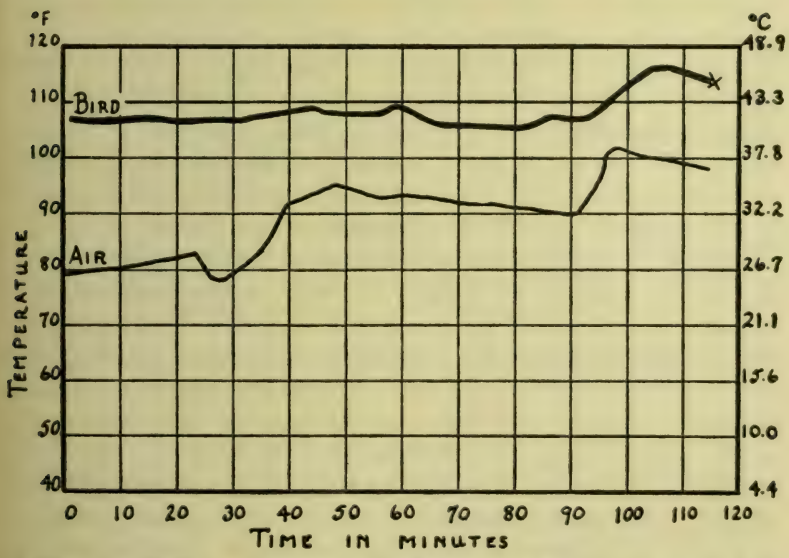


FIGURE 6.—EFFECT OF A HIGH AND RISING AIR TEMPERATURE ON THE BODY TEMPERATURE OF AN ADULT EASTERN HOUSE WREN, IN CONFINEMENT. The cross marks point of bird's death.

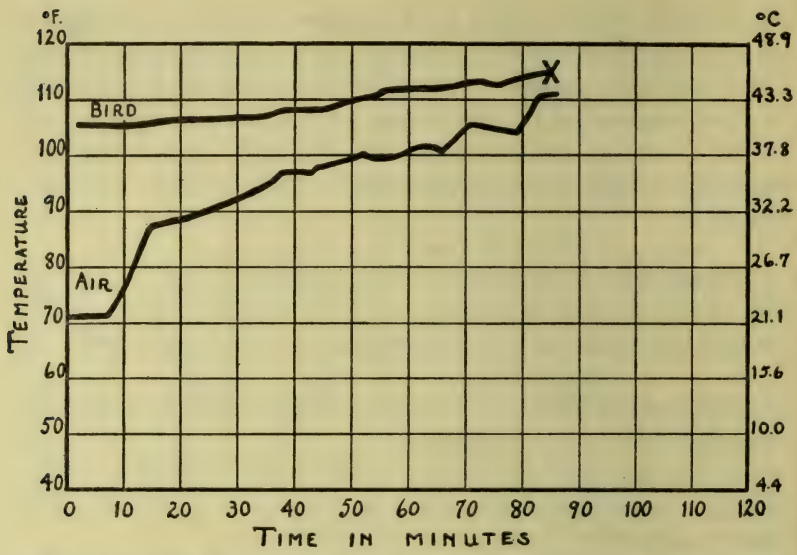


FIGURE 7.—EFFECT OF A HIGH AND RISING AIR TEMPERATURE ON THE BODY TEMPERATURE OF AN ADULT EASTERN HOUSE WREN IN CONFINEMENT. The cross marks point of bird's death.

has been obtained in the laboratory (page 32). These temperatures are not lethal, although they probably represent the maximum body temperature attained under natural conditions. In four experimental cases (Figures 6 and 7) death occurred in eastern house wrens after their body temperature had risen respectively to 116.1° F. (46.7° C.), 115.9° F. (46.6° C.), 115.1° F. (46.2° C.), and 118.2° F. (47.9° C.). The average of the records is 116.3° F. (46.8° C.). In two other instances, body temperatures caused to rise to 113.0° F. (45.0° C.) and 114.0° F. (45.6° C.) respectively, did not produce death. The temperature of 116.3° F. (46.8° C.) may be taken, therefore, as the approximate upper lethal body temperature.

A peculiar feature in this connection is that in 3 out of the 4 cases that resulted in death, the body temperature of the bird dropped from the maximum point before death actually occurred, although, in 2 out of these 3 cases, the air temperature remained nearly constant. The amount of this drop in body temperature was 2.5° F. (1.4° C.) and 8.3° F. (4.6° C.) respectively;

while in the third, in which the bird was removed to a cool room, it amounted to 26.1° F. (14.5° C.). This break and drop in body temperature is correlated with a decrease in the rate of the respiratory movements (page 54). Possibly the beginning of the drop marks the point of the breaking down of the physiological constitution of the organism, beyond which recovery is impossible. Death in cold-blooded organisms as a result of high temperatures is usually attributed to the coagulation and precipitation of proteins in the protoplasm. Probably something of the sort occurs here, but the precise cause of death from high temperatures in warm-blooded animals still needs to be determined. Pütter (1911) discusses some of the theories for the death of animals at high temperatures, and suggests that it may be due to the suffocation of the cells, on account of their inability to get sufficient oxygen at a rate rapid enough for their greatly increased metabolism.

The average temperature of the air at the time the maximum body temperatures of the birds were reached in the four instances was 100.2° F. (37.9° C.). Although birds are quickly affected by high air temperatures, this air temperature of 100.2° F. (37.9° C.) does not necessarily represent the upper limit of tolerance for the bird under natural conditions, because the birds in these experiments were in confinement under artificial unnatural laboratory conditions. In other experiments not here reported, where natural conditions were more closely imitated, birds have withstood higher air temperatures for short periods.

Lower lethal body temperature.—Over 50 birds of 13 species (Table VIII) were used for studying the effect of low body temperatures (Figures 8 and 9). Use was made of the same apparatus discussed in the preceding two sections. The object of the experiments was to lower the air temperature until the temperature control mechanism in the bird was broken, then determine the lowest body temperature that could be endured. The birds were taken directly from the traps and used in the experiments, and so all were probably well supplied with food in their digestive tracts at the beginning of the experiments. Nevertheless the temperature control mechanism of the bird was easily broken because of the unnatural confinement of the bird, in which there was little opportunity for movement or for fluffing out the feathers. In

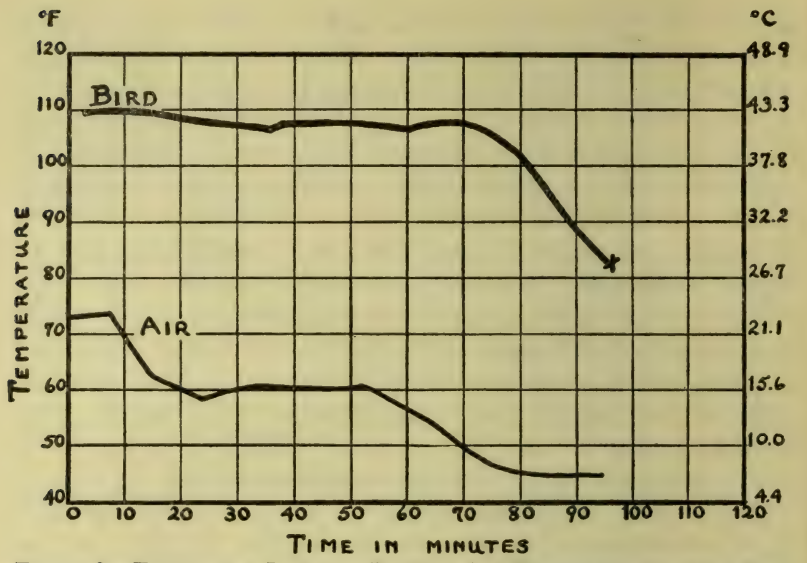


FIGURE 8.—EFFECT OF A LOW AND FALLING AIR TEMPERATURE ON THE BODY TEMPERATURE OF AN ADULT EASTERN HOUSE WREN IN CONFINEMENT. The cross marks point of bird's death.

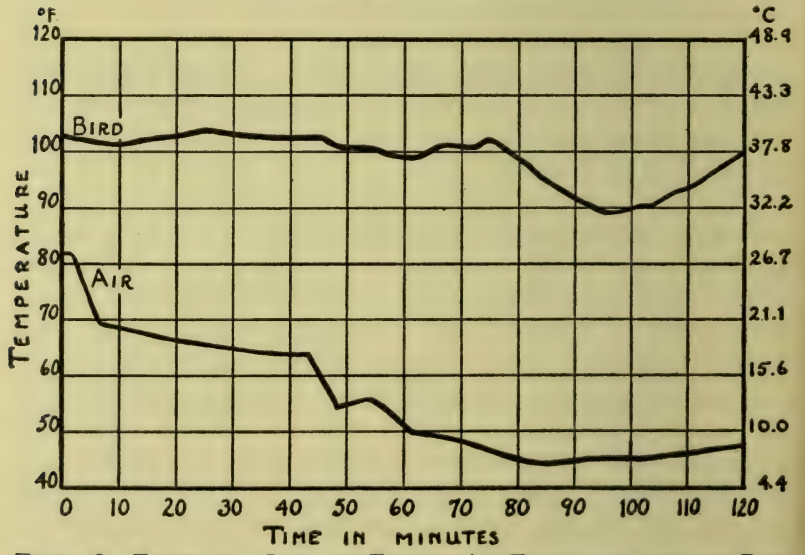


FIGURE 9.—EFFECT OF A LOW AND FALLING AIR TEMPERATURE ON THE BODY TEMPERATURE OF AN ADULT EASTERN HOUSE WREN IN CONFINEMENT. Note how the bird's temperature rises near the end, even though the air temperature remains nearly continuously low.

the case of 16 more carefully controlled experiments with the eastern house wren, the temperature of the air averaged 50° F. (10° C.) at the time that the temperature control mechanisms of the birds were broken and body temperatures began to drop rapidly below normal. This air temperature does not represent, however, the limit of tolerance for the bird under natural conditions.

Birds may recover their control of body temperature even after their temperature has fallen considerably below normal (Table VIII). This is well illustrated in Figure 9. The body temperature of this particular bird returned to its former high level even though previously it had fallen to 89.1° F. (31.7° C.), and this was accomplished entirely on the bird's own resources, without application of outside heat and while the air temperature remained below 48° F. (8.9° C.). Other birds, however, had to be returned to a warm room or even placed in an incubator before they were able to regain their normal body temperatures.

TABLE VIII.—*Number of Cases in Which Adult Birds Have Recovered Their Normal Temperature after Their Body Temperature Had Been Reduced Experimentally to the Indicated Levels*[1]

Species	100–95° F. (37.8°–35.0° C.)	95–90° F. (35.0°–32.2° C.)	90–85° F. (32.2°–29.4° C.)	85–80° F. (29.4°–26.7° C.)	80–75° F. (26.7°–23.9° C.)	75–70° F. (23.9°–21.1° C.)
Eastern house wren	26	19	7	4	2	1
Eastern cardinal	5	1	.....	.....	.....	.....
Catbird	5	3	.....	.....	.....	.....
Eastern bob-white	4	2	.....	.....	.....	.....
Eastern chipping sparrow	4	3	.....	.....	.....	.....
Eastern song sparrow	3	.....	.....	.....	.....	.....
Eastern field sparrow	1	.....	.....	.....	.....	.....
Red-eyed towhee	1	.....	.....	.....	.....	.....
Brown thrasher	2	1	.....	.....	.....	.....
Eastern cowbird	1	1	.....	.....	.....	.....
Northern yellow-throat	1	.....	.....	.....	.....	.....
Northern downy woodpecker	1	1	1	.....	.....	.....
Eastern mourning dove	1	1	.....	.....	.....	.....

[1]No deaths occurred.

Table VIII shows very clearly that the body temperature of several species of birds may be reduced to 90° F. (32.2° C.), at least, without danger that death will occur, although their normal temperatures are above 104° F. (40° C.).

In the case of the eastern house wren, a special study was made to determine actually how low the body temperature could be reduced and still allow recovery. The lowest such record obtained was 74.6° F. (23.7° C.). Although this body temperature was maintained only a few minutes it was necessary to work with the bird placed in an incubator for more than 1.5 hours before the normal body temperature was regained. The bird was liberated in an active condition. The low body temperature attained was very clearly close to the lethal point.

The next objective was to determine the actual degree of body temperature at which death occurs. Two adult house wrens were used. Death in one of these birds occurred when the body temperature had dropped to only 82.2° F. (27.9° C.). This is abnormally high and represents an exceptional condition. The other bird did not die until its body temperature had been reduced to 71.0° F. (21.7° C.). This degree of temperature appears to be more nearly correct, and when taken with the records in Table VIII, indicates that the lower lethal body temperature in the eastern house wren and possibly other passeriform species is approximately 71.0° F. (21.7° C.).

Death of birds from low temperature is not due, therefore, to "freezing," since they died a long time before the freezing temperature was reached. Ansiaux (1890) performed experiments similar to these on dogs, and came to the conclusion that death from low temperature was due to a stopping of the heart-beat, which resulted in a cerebral anemia. Respiratory movements persisted after the circulation of blood had entirely ceased. Britton (1922), working on cats, supposes that death at low temperature is due to a paralysis of the respiratory center.

RATE OF RESPIRATORY MOVEMENTS AT DIFFERENT BODY TEMPERATURES

Numerous studies by various workers have shown that the speed of physiological processes varies directly with the temperature until a certain high point is reached, above which there is usually a decline or a slowing up of the rate. This principle is rather easily demonstrable on cold-blooded organisms. In warm-blooded forms the tendency probably remains fundamentally the same, but

here the different physiological processes are more highly organized, and their relation to each other is so much more intricate that the effect of temperature is not always so apparent. Then, too, the presence of a regulating mechanism for the maintenance of a fairly uniform body temperature further complicates the relationship.

In this study, it was possible to determine the rate of the respiratory movements of the same bird at different body temperatures. This was done simply enough by actually counting, with watch in hand, the exhalations and inhalations, and getting the rate per minute. This was done while the birds were subjected to the high and low body temperatures discussed in the above sections. The rates, as determined on several individuals of each sex, are given in Table IX.

As the available records of the eastern house wren are more than of other species and cover a wider range of temperatures, more detailed discussion is possible with that species (Figure 10). At

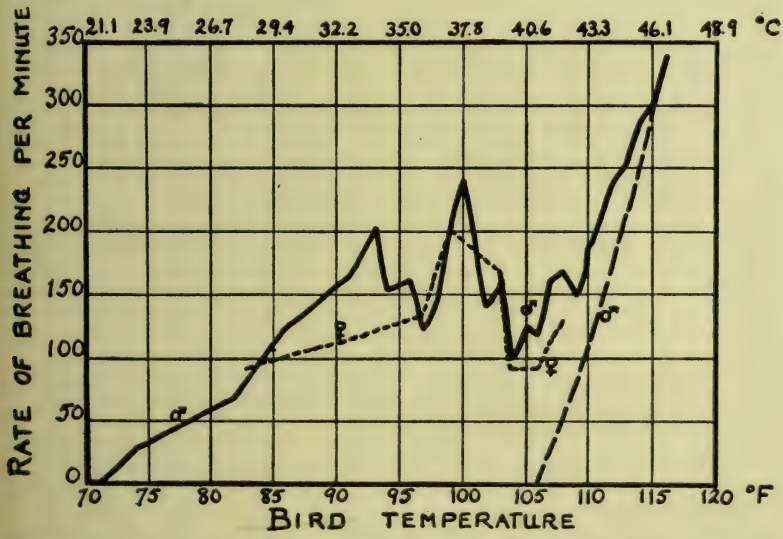


FIGURE 10.—RATE OF BREATHING MOVEMENTS IN THE ADULT EASTERN HOUSE WREN AT DIFFERENT BODY TEMPERATURES. The continuous line is for the male; the short broken line is for the female. The long broken line (for the male) at right shows how rapidly the breathing rate decreases as the body temperature falls, after reaching the upper lethal body temperature.

TABLE IX.—*Rate of Respiratory Movements at Different Body Temperatures*

Eastern House Wren (Adults)

Body Temperature	Male		Female	
	Number of Records	Average Rate per Minute	Number of Records	Average Rate per Minute
71° F. (21.7° C.)	1	0 (death)	..	..
74° F. (23.3° C.)	1	28	..	..
82° F. (27.8° C.)	1	68	..	..
83° F. (28.3° C.)	..	..	1	92
86° F. (30.0° C.)	2	122	..	..
88° F. (31.1° C.)	..	..	1	106
91° F. (32.8° C.)	1	164	..	..
93° F. (33.9° C.)	1	202	..	..
94° F. (34.4° C.)	1	152	..	..
96° F. (35.6° C.)	1	160	..	..
97° F. (36.1° C.)	1	122	1	136
98° F. (36.7° C.)	2	144	..	..
99° F. (37.2° C.)	3	201	1	200
100° F. (37.8° C.)	1	240	..	..
102° F. (38.9° C.)	4	140	..	..
103° F. (39.4° C.)	5	165	2	166
104° F. (40.0° C.)	19	100	1	91
105° F. (40.6° C.)	17	126	8	92
106° F. (41.1° C.)	10	118	13	93
107° F. (41.7° C.)	4	163	7	113
108° F. (42.2° C.)	3	170	5	130
109° F. (42.8° C.)	2	146	..	..
110° F. (43.3° C.)	2	188	..	..
112° F. (44.4° C.)	1	240	..	..
113° F. (45.0° C.)	1	256	..	..
114° F. (45.6° C.)	1	288	..	..
115° F. (46.1° C.)	1	300	..	..
116° F. (46.7° C.)	1	340	..	..
115° F. (46.1° C.)[1]	1	324	..	..
114° F. (45.6° C.)[1]	1	248	..	..
113° F. (45.0° C.)[1]	1	214	..	..
106° F. (41.1° C.)[1]	1	0	..	..

[1]Body temperature decreasing after upper lethal temperature reached.

Eastern Robin

104° F. (40.0° C.)	..	..	1	48
105° F. (40.6° C.)	3	40	..	..
106° F. (41.1° C.)	8	49	1	40
107° F. (41.7° C.)	2	66	..	..
108° F. (42.2° C.)	2	74	1	79
109° F. (42.8° C.)	1	94	..	..

TABLE IX (Continued).—*Rate of Respiratory Movements at Different Body Temperatures*

White-breasted Nuthatch, Male

Body Temperature	Number of Records	Average Rate per Minute
106° F. (41.1° C.)	1	65
107° F. (41.7° C.)	1	108

Eastern Chipping Sparrow

Body Temperature	Male		Female[1]	
	Number of Records	Average Rate per Minute	Number of Records	Average Rate per Minute
98° F. (36.7° C.)	1	108	..	..
104° F. (40.0° C.)	2	81	..	..
105° F. (40.6° C.)	10	75	1	77
106° F. (41.1° C.)	5	91	7	74
107° F. (41.7° C.)	3	97	4	64
108° F. (42.2° C.)	1	104	2	120
109° F. (42.8° C.)	1	157	1	140
111° F. (43.9° C.)	1	147	..	..
112° F. (44.4° C.)	..	..	1	157

[1]In one female not included in the averages, the rate per minute at 105° F. (40.6° C.) was 200, at 108° F. (42.2° C.), 219, due possibly to factors other than temperature.

Northern Downy Woodpecker, Male

Body Temperature	Number of Records	Average Rate per Minute
99° F. (37.2° C.)	1	88
104° F. (40.0° C.)	2	108
109° F. (42.8° C.)	1	131

Eastern Hairy Woodpecker, Female

Body Temperature	Number of Records	Average Rate per Minute
105° F. (40.6° C.)	2	130
107° F. (41.7° C.)	3	129

Eastern Yellow Warbler, Female

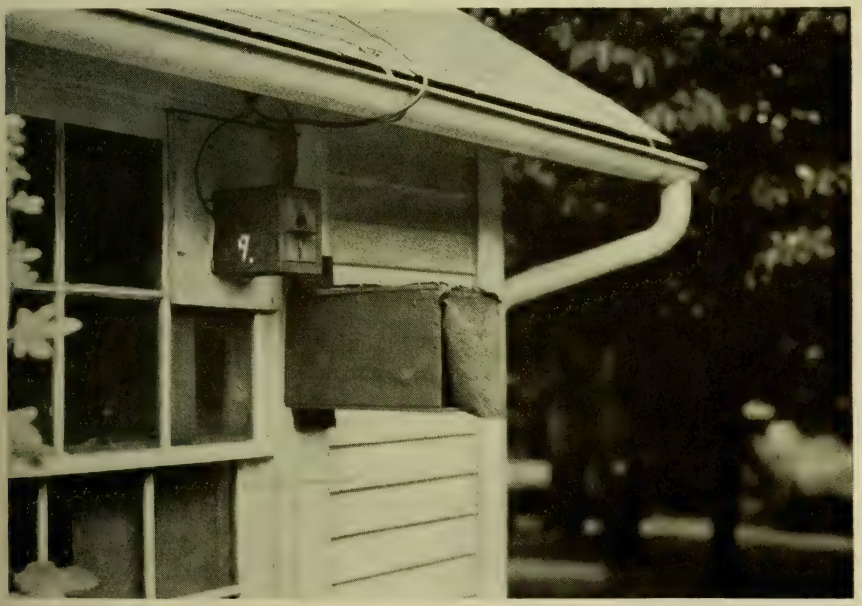
Body Temperature	Number of Records	Average Rate per Minute
104° F. (40.0° C.)	1	132

standard temperature (male, 104.4° F. [40.2° C.]; female, 105.0° F. [40.6° C.]), the rate of the respiratory movements is less than at body temperatures either directly below or above this standard temperature. This is to be expected, since the bird when at standard temperature is at complete rest and relaxation. As the body temperature rises the rate of respiration greatly increases until the upper lethal limit is reached; then it decreases. In 2 out of 3 instances this decrease was correlated with a drop also in body temperature. The highest rate recorded for the house wren is 340 times a minute in a male at a body temperature of 116° F. (46.7° C.).

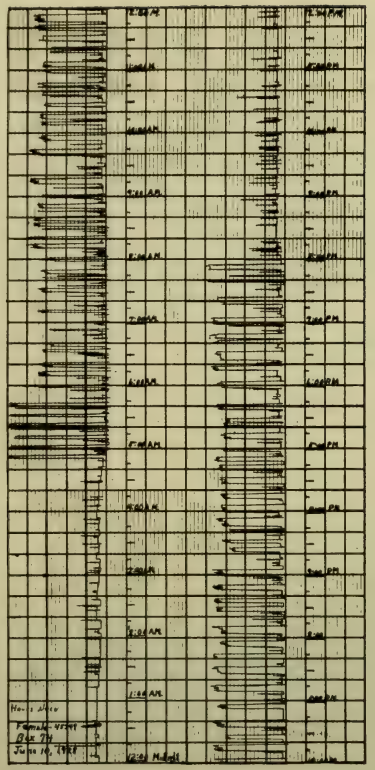
As the body temperature falls below the standard level, the breathing increases in rate until it becomes very rapid at a body temperature of 100° F. (37.8° C.), but then begins a more or less fluctuating decline until death results. The low rate of breathing at standard temperature is due, as suggested, to the complete relaxation of the bird. As the temperature drops or rises from this, the bird awakens, becomes more or less active, and as a result breathing increases. High normal body temperature occurs only after considerable activity or excitement of the bird, which would also cause increase of respiration. At high temperature, also, the increase of breathing is due to an attempt of the regulating mechanism to increase the heat loss from the body. As the temperature control is broken at the upper limit, the breathing rate decreases, probably due to the general disablement of the body.

As the body temperature drops below the standard level to 100°, the increase in breathing is due largely to the activity of the bird. It would be interesting to know the part played by the air sacs in the breathing. One would expect that there is a rapid and thorough aeration of the air sacs in the increased breathing at high body temperatures and a complete closure of them at these low temperatures. As the body temperature drops below 100° F. (37.8° C.), the temperature control is broken and the breathing decreases. The rise in the rate at a body temperature of 93° F. (33.9° C.) may be due partly to increased activity, but may, in addition, have some particular significance in the respiratory mechanism, though at present this is not clear. If the normal range of the bird's temperature be considered as from 102.0° F. (38.9° C.) to 113.0° F. (45.0° C.), the rate of 256 times per minute is the maximum rate

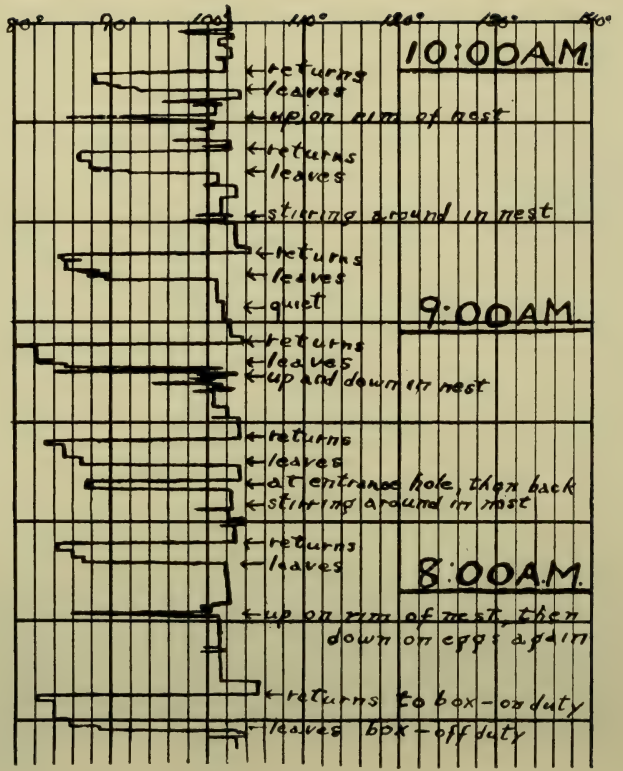
A.—Nest of an Eastern House Wren in a Box Showing Position of a Thread Thermocouple above the Eggs.



B.—Nest Box of an Eastern House Wren Showing the Thermocouple Wires That Connect the Nest with the Recording Potentiometer in the Laboratory. The larger box at the right shelters a thermograph which records air temperature.



A.—Type of Daily Record of Bird Temperature, Obtained by a Recording Potentiometer Connected with the Nest of an Eastern House Wren.



B.—Details of a Portion of a Daily Record of the Body Temperature of an Eastern House Wren, Correlated with the Bird's Activity during Attentive and Inattentive Periods.

of respiration in the normal behavior of the bird. In a few instances it has been possible to count at close range the breathing of female house wrens as they incubated their eggs without their being aware of the presence of man. Records obtained varied from 128 to 140 times per minute, but these observations are too limited for the setting of any limits for the rate at different times and circumstances under natural conditions.

The breathing rate is variable both in the individual bird and in different individuals. While watching particular individuals, under constant conditions, periods may be discerned when the breathing is accelerated, while at other times it is diminished. The breathing rate in different individuals may vary considerably even when their body temperatures are approximately the same. Undoubtedly other factors besides temperature are involved in the determination of this rate.

A comparison of the rate of breathing for the different species given in Table IX, particularly at standard temperatures (104°–105° F. [40.0°–40.6 C.]), shows that the eastern robin has the slowest rate. The eastern chipping sparrow breathes faster than the eastern robin but somewhat more slowly than the eastern house wren. The rate for the eastern house wren is comparatively high, although equalled by that of the two woodpeckers. The single record for the eastern yellow warbler is high.

There is also a difference between the sexes in the rate of respiration. This is very marked in the eastern house wren at and about the level of standard temperature (104°–106° F. [40.0°–40.6° C.]), the rate for the male averaging 112 (46 records) and for the female 92 (22 records). This is a difference of 20 in favor of the male. A difference in favor of the male continues as the body temperature increases at least as far as 108° (42.2° C.), after which it probably disappears. Below the standard level, the rate appears to be approximately the same in the two sexes. This difference in breathing rate at the standard temperature is just the reverse of the difference in the standard temperature between the two sexes, and may for this reason have some significance. With more rapid respiration, the body would become cooled faster, and hence the standard temperature in the male would reasonably be lower even if the metabolism were nearly equal.

SKIN TEMPERATURE

Recently Kallir (1930), using copper-constantan thermocouples, has obtained skin temperatures of some 10 species of birds. He found that the skin temperature was highest under the wings, over the furcula, and possibly on the upper rump. The head and the region above the base of the tail have the lowest temperature of the entire body with the exception of the unfeathered legs. The temperature of the last varies considerably with the surrounding air temperature. He also found that the skin temperature of a dove without feathers was lower than in a normal animal. In young sparrows, before the development of a temperature control, he found that the skin temperature varied with that of the surrounding air. This paper brings up several interesting points. Kallir gives data also on the temperature of various internal organs.

In the eastern house wren, it was desirable to determine the relation between the body temperature and skin temperature of different portions of the body, partly to furnish data for aid in a study of the temperature controlling mechanism of the bird; partly to investigate the relation between the body temperature of the bird and the temperature applied to eggs in incubation; and partly to correlate with the body temperature the skin temperature records obtained of the bird as she sits in the nest.

The skin temperature was taken with a loop thermocouple (page 16, Plate I–A). One person held the bird gently and loosely in the left hand, and with the right hand thrust the sensitive junction of this loop under the feathers. He then pressed down the feathers lightly over the outside of the thermocouple so that temperatures as normal as possible of the skin beneath the feathers could be obtained. Another person manipulated the indicator potentiometer, and read and recorded the results. Care was taken to read the body temperature of the bird by another thermocouple thrust down its throat just before and sometimes also just after the skin temperature was taken, so that errors due to normal fluctuations in the body temperature could be eliminated. The two thermocouples used for comparing these temperatures were tested under controlled conditions and found to be reading within a tenth of a degree of each other.

In Table X, all the measurements of the skin temperature of house wrens are compiled for different parts of the body, at different body temperatures, and separately for each sex.

From Table X it is seen that belly temperatures in males and females average the same; that the breast of the female averages 1.7° F. (1.0° C.) warmer than the breast of the male; that the temperature of the side of the body in the female is the same as in the male; and that the back of the female is 1.0° F. (0.6° C.) cooler. This relation will be clearer if we assume 108.5° F. (42.5° C.) as the body temperature of both male and female, then the skin temperatures would be as shown in Table XI.

It is interesting that the breast temperature of the male is so much lower than that of the female. This would seem to indicate that the circulation of blood must be better and richer in this region

TABLE X.—*Skin Temperature of the Eastern House Wren*
Female (15 Birds)

Body Temperature	Number of Records of Belly Temperature	Average Difference between Belly and Internal Body Temperature	Number of Records of Breast Temperature	Average Difference between Breast and Internal Body Temperature
112°–113° F. (44.4°–45.0° C.)	2	—1.8° F. (1.0° C.)	..	.....
111°–112° F. (43.9°–44.4° C.)	2	—1.5° F. (0.8° C.)	..	.....
110°–111° F. (43.3°–43.9° C.)	6	—1.3° F. (0.7° C.)	6	—2.2° F. (1.2° C.)
109°–110° F. (42.8°–43.3° C.)	15	—1.4° F. (0.8° C.)	17	—1.5° F. (0.8° C.)
108°–109° F. (42.2°–42.8° C.)	15	—1.4° F. (0.8° C.)	38	—1.0° F. (0.6° C.)
107°–108° F. (41.7°–42.2° C.)	15	—1.2° F. (0.7° C.)	34	—1.0° F. (0.6° C.)
106°–107° F. (41.1°–41.7° C.)	13	—1.0° F. (0.6° C.)	20	—1.2° F. (0.7° C.)
105°–106° F. (40.6°–41.1° C.)	8	—1.1° F. (0.6° C.)	12	—1.1° F. (0.6° C.)
104°–105° F. (40.0°–40.6° C.)	6	—0.8° F. (0.4° C.)	3	—1.1° F. (0.6° C.)
	Total 82	Average —1.3° F. (0.7° C.)	Total 130	Average —1.3°.F. (0.7° C.)

Body Temperature	Number of Records on Side of Body	Average Difference between Side of Body and Internal Body Temperature	Number of Records of Back Temperature	Average Difference between Back and Internal Body Temperature
112°–113° F. (44.4°–45.0° C.)	..	.....	..	.....
111°–112° F. (43.9°–44.4° C.)	..	.....	..	.....
110°–111° F. (43.3°–43.9° C.)	..	.....	..	.....
109°–110° F. (42.8°–43.3° C.)	2	—2.0° F. (1.1° C.)	2	—3.9° F. (2.2° C.)
108°–109° F. (42.2°–42.8° C.)	8	—1.8° F. (1.0° C.)	2	—2.8° F. (1.6° C.)
107°–108° F. (41.7°–42.2° C.)	2	—1.8° F. (1.0° C.)	5	—2.2° F. (1.2° C.)
106°–107° F. (41.1°–41.7° C.)	1	—1.8° F. (1.0° C.)	2	—2.4° F. (1.3° C.)
105°–106° F. (40.6°–41.1° C.)	..	.....	2	—3.2° F. (1.8° C.)
104°–105° F. (40.0°–40.6° C.)	..	.....	..	.....
	Total 13	Average —1.8° F. (1.0° C.)	Total 13	Average —2.9° F. (1.6° C.)

TABLE X (Continued).—*Skin Temperature of the Eastern House Wren*
Males (9 Birds)

Body Temperature	Number of Records of Belly Temperature	Average Difference between Belly and Internal Body Temperature	Number of Records of Breast Temperature	Average Difference between Breast and Internal Body Temperature
110°–111° F. (43.3°–43.9° C.)	..	.....	4	—3.2° F. (1.8° C.)
109°–110° F. (42.8°–43.3° C.)	2	—1.4° F. (0.8° C.)	6	—3.2° F. (1.8° C.)
108°–109° F. (42.2°–42.8° C.)	4	—1.4° F. (0.8° C.)	12	—2.7° F. (1.5° C.)
107°–108° F. (41.7°–42.2° C.)	5	—1.5° F. (0.8° C.)	6	—2.9° F. (1.6° C.)
106°–107° F. (41.1°–41.7° C.)	6	—1.1° F. (0.6° C.)	..	.....
105°–106° F. (40.6°–41.1° C.)	2	—1.0° F. (0.6° C.)	..	.....
104°–105° F. (40.0°–40.6° C.)	..	.....	..	.....
	Total 19	Average —1.3° F. (0.7° C.)	Total 28	Average —3.0° F. (1.7° C.)

Body Temperature	Number of Records on Side of Body	Average Difference between Side of Body and Internal Body Temperature	Number of Records of Back Temperature	Average Difference between Back and Internal Body Temperature
110°–111° F. (43.3°–43.9° C.)	..	.....	..	.....
109°–110° F. (42.8°–43.3° C.)	..	.....	..	.....
108°–109° F. (42.2°–42.8° C.)	6	—2.0° F. (1.1° C.)	2	—2.5° F. (1.4° C.)
107°–108° F. (41.7°–42.2° C.)	5	—2.4° F. (1.3° C.)	3	—1.6° F. (0.9° C.)
106°–107° F. (41.1°–41.7° C.)	5	—1.7° F. (1.0° C.)	6	—2.2° F. (1.2° C.)
105°–106° F. (40.6°–41.1° C.)	4	—1.2° F. (0.7° C.)	4	—1.7° F. (1.0° C.)
104°–105° F. (40.0°–40.6° C.)	..	.....	2	—1.7° F. (1.0° C.)
	Total 20	Average —1.8° F. (1.0° C.)	Total 17	Average —1.9° F. (1.1° C.)

in the female during the breeding season than in the male. However, the fact that the back of the male is a whole degree higher than in the female may indicate that the difference in the skin temperature between the sexes may be due to some other cause.

In the female the feathers are lost from both the belly and breast during the breeding season and the skin becomes loose and

TABLE XI.—*Average Differences in Skin Temperature between Sexes of the Eastern House Wren*

	Male	Female
(Body)	(108.5° F. [42.5° C.])	(108.5° F. [42.5° C.])
Belly	107.2° F. (41.8° C.)	107.2° F. (41.8° C.)
Breast	105.5° F. (40.8° C.)	107.2° F. (41.8° C.)
Side	106.7° F. (41.5° C.)	106.7° F. (41.5° C.)
Back	106.6° F. (41.4° C.)	105.6° F. (40.9° C.)

wrinkled. This facilitates the close application of heat to the eggs. The loss of feathers is completed during the first egg laying period, and does not occur in the male. That this loss of feathers is important is shown by the following record obtained of a female before she had begun to lose her belly feathers. Her body temperature at that time was 109.2° F. (42.9° C.), the temperature on the outside surface of the feathers was 97.0° F. (36.1° C.), partly under the feathers, 101.2° F. (38.4° C.), and next the skin, 107.8° F. (42.1° C.). The air temperature was about 60° F. (15.6° C.). Thus by shedding its feathers, the bird was enabled to apply a temperature to the eggs 10° F. (5.6° C.) higher than it otherwise would have been able. The looseness and consequent wrinkling of the skin is due to the release of skin from the base of the calami of the feathers when these are lost.

The relation between internal body and skin temperatures does not remain exactly constant at all body temperatures. This is brought out to some extent in the averages shown in Table X, but is even more evident in cases of some individual birds. The tendency is toward a greater difference between body and skin temperatures when the bird's temperature is high than when it is low. When the bird is first caught and its temperature is taken, the difference between skin and body temperatures is large. This seems to indicate that in the bird's excitement and exertion, the internal body temperature rose more rapidly than did the skin temperature. As the bird is held gently in one's hand, it becomes quiet, and its temperature drops. However, the body temperature drops more rapidly than does the skin temperature, so that the difference between the two becomes less than it was at first. This shows that the body temperature is more rapidly variable than the skin temperature. This would be possible only if temperature regulation is carried out mainly through the respiration and not through the skin. The probable manner of temperature regulation will be discussed more fully in a later section (page 94).

In the nude human subject, it has been shown that the temperature of the skin varies with air temperature (Benedict, Miles, and Johnson, 1919). One would expect considerably less correlation in this respect in birds, because their skin is covered with an efficient insulating coat of feathers. Even in the case of incubating females that have lost most of the feathers from the mid-

ventral surface of the body, this area is well covered by the overlapping of feathers from the side when the bird is off the nest.

On 5 different female house wrens, several determinations of the skin temperature were made of breast and belly with the feathers drawn back so that the skin and thermocouple were exposed. No consistent difference in readings was obtained from those taken with the skin and thermocouple well covered with feathers. The bird is so small and the circulation of blood is apparently so rapid that when only a small area of the skin is exposed, no appreciable lowering of skin temperature occurs.

A test was next made to determine whether or not the skin temperature is affected when the air temperature is lowered. A series of determinations of skin temperature on 6 female house wrens was first made at ordinary high room temperatures of mid-summer. The bird was then placed in a damp basement room of lower air temperature and left for 1.25 hours before another comparable series of readings was taken at the lower degree. The results are shown in Table XII. All the readings were taken with the skin and thermocouple covered with feathers.

A study of Table XII shows that a lowering of 14° F. (7.8° C.) in air temperature is correlated with a lower belly temperature in

TABLE XII.—*Relation between Skin and Internal Body Temperatures of the Female Eastern House Wren at Different Air Temperatures*

Band Number of Bird	Air Temperature	Number of Records of Belly Temperature	Difference between Belly and Internal Body Temperature	Number of Records of Breast Temperature	Difference between Breast and Internal Body Temperature
F45565	86° F. (30.0° C.)	5	—1.3° F. (0.7° C.)	7	—1.1° F. (0.6° C.)
C94314	87° F. (30.6° C.)	5	—1.2° F. (0.7° C.)	7	—0.9° F. (0.5° C.)
C68978	88° F. (31.1° C.)	4	—0.4° F. (0.2° C.)	8	—1.2° F. (0.7° C.)
F45745	86° F. (30.0° C.)	4	—1.2° F. (0.7° C.)	8	—1.1° F. (0.6° C.)
F45359	88° F. (31.1° C.)	3	—0.8° F. (0.4° C.)	7	—1.2° F. (0.7° C.)
C94401	88° F. (31.1° C.)	4	—1.1° F. (0.6° C.)	8	—1.3° F. (0.7° C.)
Average of 6 birds....	87° F. (30.6° C.)	(25)	—1.0° F. (0.6° C.)	(45)	—1.1° F. (0.6° C.)
F45565	72° F. (22.2° C.)	4	—1.1° F. (0.6° C.)	9	—1.5° F. (0.8° C.)
C94314	72° F. (22.2° C.)	3	—1.0° F. (0.6° C.)	6	—1.0° F. (0.6° C.)
C68978	73° F. (22.8° C.)	4	—1.6° F. (0.9° C.)	11	—1.7° F. (1.0° C.)
F45745	73° F. (22.8° C.)	4	—1.3° F. (0.7° C.)	8	—1.0° F. (0.6° C.)
F45359	74° F. (23.3° C.)	4	—1.4° F. (0.8° C.)	6	—1.2° F. (0.7° C.)
C94401	74° F. (23.3° C.)	3	—0.9° F. (0.5° C.)	7	—1.1° F. (0.6° C.)
Average of 6 birds....	73° F. (22.8° C.)	(22)	—1.2° F. (0.7° C.)	(47)	—1.2° F. (0.7° C.)

3 instances and a higher belly temperature in 3 other instances. The breast temperature is lower in 3 cases, higher in 2, and the same in 1. Apparently the variations noted are largely those that may occur under any circumstances and are not due to differences in air temperature. In the averages for all 6 birds, the one-tenth or two-tenths of a degree difference is too small to have any great significance. The inference from these data is that the peripheral circulation of blood is so rapid and perfect and the skin is so well insulated with feathers, that variations in air temperature to which birds are exposed do not greatly affect the relation between skin and body temperatures.

It would be desirable for the sake of comparison to have available on other species than the house wren a series of skin temperatures like those above. We have only a few on hand. Twelve records on 3 other species of Passeriformes give an average belly temperature of 1.2° F. (0.7° C.) below that of the body. In the early part of these investigations we took a series of skin temperature readings with the mercury thermometer. Ten records on 7 passeriform species gave an average belly temperature of 1.0° F. (0.6° C.) below that of the body. Although these data are too inadequate for comprehensive discussion, they indicate that the skin temperature of some other small passeriform species during the breeding season is similar to that of the house wren.

To summarize: the skin temperature of small passeriform species is always lower than the body temperature; is less variable than body temperature; is not the same on different parts of the body; is not the same in both sexes on all parts of the body; and is unaffected by moderate changes in air temperature.

BODY TEMPERATURE OF BIRDS UNDER NATURAL CONDITIONS

Practically all the discussion concerning the temperature of birds in the preceding pages has been with the bird under more or less controlled and experimental conditions. In the following pages, there is considered the normal temperature of adult birds in their free natural environment. Because of obvious difficulties, this discussion pertains only to the female during the incubation period. One is probably justified, however, in believing that the male

reacts to the same conditions as the female and in much the same manner.

So far as we have been able to ascertain, there has been no previous work done on the temperature of free wild birds under natural conditions, hence there is no literature on the subject to review. The eastern house wren is the principal species of our research, although records on several other species have been obtained.

Method.—To obtain readings of temperature of an adult bird as she sat on her eggs in the nest, use was made of a thread thermocouple (Plate I–A). This was stretched across the nest from one side to the other slightly above the eggs, so that the sensitive junction came halfway across the nest (Plate IV–A). The wire was not made so tight or rigid as to annoy the adult bird when she came in to incubate, but was fastened with sufficient firmness that it could not be pulled out of position. As it is sufficiently flexible to permit some adjustment by the adult bird to suit her comfort, it is much like a coarse thread over the eggs. When the bird came in and sat down on her eggs to incubate them, she necessarily had to sit on this thermocouple wire. Her weight was sufficient to press down the wire to the top level of the eggs so that normal incubation was not interfered with, yet the wire was taut enough to keep the sensitive thermojunction continuously pressed against her skin. In this way the skin temperature of the bird while she sat in the nest could be obtained. The thermocouple wires ran back from the nest to some building or shelter near by where temperature records were obtained by the use of indicator and recording potentiometers, without the bird's being in the least aware that they were being taken (Plate IV–B).

One objection to this method that might be raised is that the presence of the wire in the nest would disturb the bird so that she would not behave or react under exactly natural conditions. In a very few instances, this actually occurred. In working with birds as well as with human beings, individuality of the subject is always a factor that must be considered. With a few individual house wrens, normal records were not obtained, and these are not considered in this discussion. In other cases, the bird would be annoyed by the wire for the first day or two, but then become so

accustomed to it as to give it no further attention. Occasionally, records could be obtained every day during the 12 or 13 days of incubation so that any slight disturbance during the first day or two was of little consequence. In a few cases, the thermocouple was placed in the nest before the set of eggs was laid or completed, and the bird became accustomed to the wire gradually. Some individual birds paid no attention at all to the wire, even from the first, and these naturally gave us the best records and our most reliable data. Through observation, the behavior of these birds in the nest was checked by birds in other nests where there were no thermocouples.

In order to interpret the records obtained in terms of body temperature, a constant had to be determined for the relation of skin temperature to body temperature in the female house wren and other species. To obtain such a constant was one of the objects in the study of skin temperature discussed above. The thermocouple in the nest obtains the skin temperature of the under side of the bird. The sensitive junction of the thermocouple rests on the lower part of the breast or on the belly. During incubation, the belly and breast of the female house wren are bare of feathers, so that there is no interference in this way. This is true of also other passeriform species. Likewise, when the incubating bird settles on the eggs she fluffs out the feathers on the side of the body, so there is generally a good contact between the skin and eggs, and also between the skin and the thermocouple.

In the study above, a difference between the temperature of the belly and breast and that of the body of 1.3° F. (0.7° C.) was obtained, the body temperature being always the higher. Therefore, adding 1.3° F. (0.7° C.) to the records of skin temperature obtained of the bird in the nest gives the approximate body temperature. This is subject to some final error, although the errors in individual records are sometimes of a plus, sometimes of a minus nature, so are largely eliminated when several hundred records are averaged, as is the case in nearly all of the following tables and figures. The probable error in the records of belly and breast temperatures of female house wrens given in Table X is $\pm$ 0.36° F. (0.20° C.). Since the body temperature records, as ordinarily obtained, are more variable than skin temperatures, as indicated in Table X, the actual fluctuations in body temperature were slightly

greater than is indicated in the tables and figures that follow, since these are built upon records of skin temperature only. The results obtained from this method of determining the normal temperature of living wild birds under natural conditions have considerable importance and reasonable accuracy. From Table XII, we see that differences in air temperature do not appreciably affect the relation between skin and body temperature, because of the rapid circulation of blood. On the same account, the cool eggs in the nest do not lower the skin temperature more rapidly than they do the body temperature.

Many records of the skin temperature of the bird in the nest were obtained during the incubation period by the use of the thermocouple arranged in the nest as just described and the indicator potentiometer. Some of these records are graphically shown in Figure 11. An addition of 1.3° F. (0.7° C.) was made so that the variations of temperature might be interpreted in terms of the body temperature of the bird.

Average temperature of female birds on the nest during incubation.—For a proper understanding of this discussion of temperature, it is desirable first to say a few words concerning periods of attentiveness and inattentiveness in the bird's nesting behavior. This is an absolutely necessary concept that must be borne continually in mind in any discussion of nesting activities, particularly with such passeriform species as the eastern house wren. In a previous paper (Baldwin and Kendeigh, 1927), we have considered this in some detail. The essential points to bear in mind are that in the case of the species here considered, the female bird, which alone sits on the eggs, does not incubate continuously all day long without interruption, but that she is, instead, almost continuously going to and from the nest (Plate V). She will sit on the eggs for a few minutes, then leave them to get something to eat for herself, return to the eggs for another period of incubation, only to leave again a few minutes later. The periods she spends engaged in the duties of reproduction we call "attentive periods," while the periods during which she is away looking after her own sustenance we call "inattentive periods." These periods alternate regularly throughout the day from the time the bird first leaves the box in the morning after a night's stay until

she settles down again at dusk. For the 12 female birds that furnished the data for this investigation, the average number of attentive periods per day was 33.7, and their average duration was 20.2 minutes. The number of inattentive periods per day averaged 34.7, and their length 7.6 minutes (Table XIII). The temperature of the bird can be obtained only during the period of attentiveness, but it can be estimated for the remaining time.

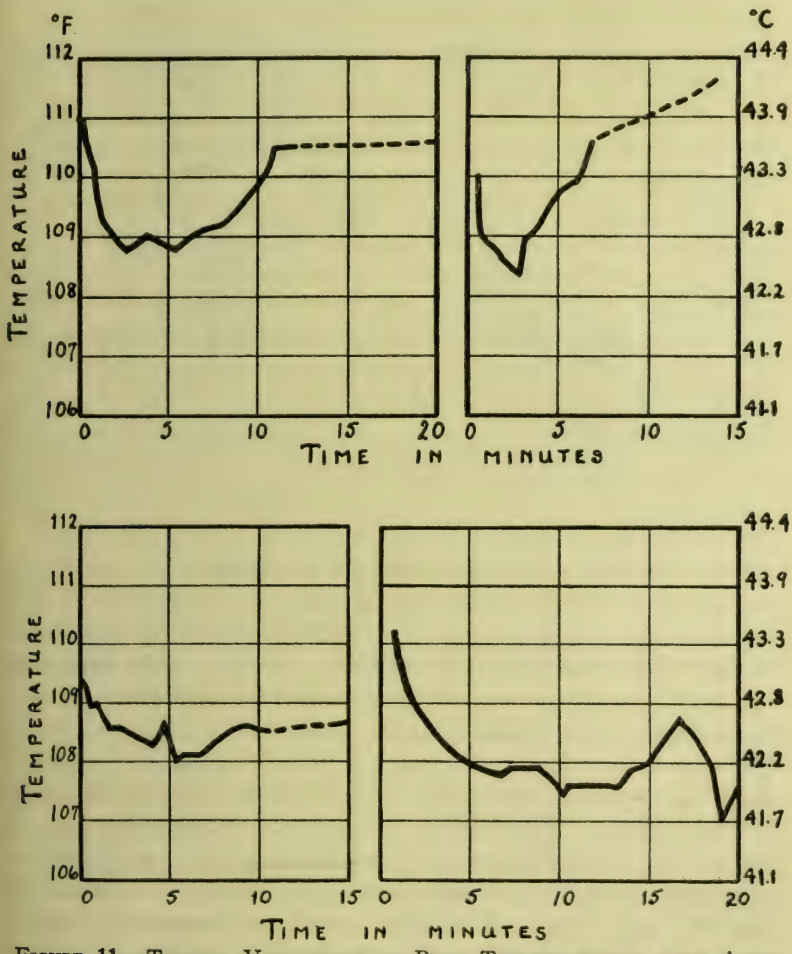


FIGURE 11.—TYPICAL VARIATIONS IN BODY TEMPERATURE OF THE ADULT FEMALE EASTERN HOUSE WREN. Shown while incubating eggs, both during periods of attentiveness (continuous line) and inattentiveness (broken line).

As may be seen from the graphs (Figure 11) the body temperature of the bird is high as it first comes to the nest after a period of absence. During the preceding inattentive period the bird has been exerting itself in flying around and hunting food, it has been taking new food into its alimentary tract, and perhaps it has been

TABLE XIII.—*Periods of Attentiveness and Inattentiveness in Various Species of Birds (Females) Whose Body Temperatures Are Given in Table XIV*

Species	Date of Records Obtained during Incubation Period	Number of Days' Record	Average Number of Attentive Periods per Day	Average Duration of Attentive Periods	Average Number of Inattentive Periods	Average Duration of Inattentive Periods per Day
				minutes		*minutes*
Eastern house wren						
(No. 1).....	July 23–30, 1929	8	45.8	8.5	46.8	10.0
(No. 2).....	July 4–18, 1930	13	45.7	12.5	46.7	7.0
(No. 3).....	May 27–June 6, 1931 ..	9	39.3	15.8	40.3	6.9
Eastern robin						
(No. 1).....	June 24–25, 1931	2	41.0	15.1	42.0	7.7
(No. 2).....	July 16–25, 1931	10	46.7	14.4	47.7	6.4
Wood thrush.....	June 12–14, 1931	3	24.5	25.9	25.5	11.4
Cedar waxwing....	July 29–August 4, 1931	7	21.7	37.4	22.7	3.8
Catbird (No. 1)...	June 21–24, 1931	4	29.2	24.4	30.2	7.0
" (No. 2)...	July 8–12, 1931	5	22.2	33.0	23.2	7.8
Eastern song sparrow	June 18–21, 1931	2	23.0	28.2	24.0	7.6
Eastern chipping sparrow	July 20–22, 1931	3	36.0	17.8	37.0	6.8
Eastern wood pewee	August 5–15, 1929	9	29.1	19.7	30.1	9.2
Grand average: 8 species, 12 females, 75 days			33.7	20.2	34.7	7.6

scolding intruders or been emotionally excited in other ways. All of these factors, as our experimental work has shown, tend to raise the bird's body temperature. The fact that the bird's temperature is high when it first comes to the nest is, therefore, easily explained.

As the bird settles down on the eggs and becomes quiet, its body temperature drops. This is the same phenomenon that occurs, as shown previously, when the bird is held in the hand. It is due almost entirely to a decrease in heat production with the inactivity of the muscles. The bird is more at ease emotionally, and instances are known, in other species, of birds' practically going to sleep during the daytime while incubating their eggs. Undoubtedly also, the eggs with their lower temperature, coming into contact with the bare skin of the breast and belly, help to augment the rate of this decrease of body temperature.

After continuing to drop for 2, 3, 5 minutes, or even longer, the body temperature may then become constant, may fluctuate more or less considerably, or begin to rise again. As long as the bird remains quiet, the temperature is fairly uniform. Ordinarily, however, the house wren stirs around intermittently, perhaps to take a new position on the eggs or to shift the position of her legs, to inspect the nest's contents, or to survey some disturbance outside. Such activity, even though slight, is almost always accompanied by a temporary rise in body temperature. Sometimes, temperatures obtained at such times may be higher than the initial temperature of the bird when it first came to the nest.

Near the end of the period of attentiveness, the temperature of the bird usually, but not always, rises. The last temperature for the attentive period is almost always higher than at some intermediate time during the period, and in some instances may approach the initial temperature. Occasionally, the last temperature may be even higher than the initial one, but this is not the rule, as usually it is somewhat lower. Sometimes, this rise in temperature at the end of the attentive period may be explained by the stirring around of the bird in the nest. In other cases, however, it appears to be due to the warming up of the eggs and nest until they demand less heat from the brooding adult, thus conserving the body heat of the adult.

During the period of inattentiveness the body temperature generally rises. The temperature at the beginning of this period may be considered the last record obtained before the bird leaves the nest, while the temperature at the end of this period is the temperature of the bird when she first returns to the nest. As has been stated before, this latter temperature is usually the higher of the two, indicating that the activity of the bird while away from the nest gathering food is sufficient to raise its temperature. In Table XIV the averages of a large number of records of these different temperatures are shown.

From this analysis of the temperature of the bird during its periods of attentiveness and inattentiveness in incubation, we may pass to more general considerations.

The data for the body temperature graphs in Figure 11 were obtained by means of the indicator potentiometer. This instru-

ment, however, must be manipulated by hand and constantly attended to if a continuous record of the bird's temperature is desired. To obtain automatically a continuous record of the bird's temperature at all hours of day and night throughout the breeding season, use was made of recording potentiometers (page 16). These give a continuous automatic record of the bird's temperature (Plate V) and require only a minimum amount of attention. Two of these instruments have been used constantly throughout the season.

More than 13,000 records of body temperature of birds have been compiled in Table XIV. These were obtained by continuous and automatic recording for a total of 75 days and nights. By *initial temperature* is meant the body temperature of the bird as she first returns to the nest after a period of absence, that is, it is the first temperature of the bird during a period of attentiveness. As this temperature is not always the highest for the period of attentiveness, a separate column is therefore provided for the *highest temperature* during the attentive period, and one, also, for the *lowest temperature*. The *last temperature* is the temperature of the bird at the end of the attentive period just before she leaves for a period of absence. Averages are obtained for these four temperatures for all the periods during each day, and then the various days are averaged together to give the temperatures for each individual as shown in the table.

The *median temperature of the attentive periods* is the median between the average highest and the average lowest temperature during the attentive periods, given in preceding columns of Table XIV. The body temperature fluctuates considerably during the attentive periods, but it is believed that the median comes as close to the true average of all these fluctuations as can be conveniently computed. The *median temperature of the inattentive periods* is, similarly, a median between two temperatures: the average last temperature of the attentive periods, which is at the same time the initial temperature of the inattentive periods, and the average initial temperature of the attentive periods, which is the last temperature of the inattentive periods. The temperature of the bird during the active daylight hours is obtained by averaging the median temperature of the bird during the periods of attentiveness and inattentiveness in proportion to the time duration of these two

periods in minutes (Table XIII). It is, therefore, the *average median temperature during the active day.* Although at night the bird sits on the eggs constantly, median temperatures for each 15 minutes are, for the purpose of analysis, read off, and these then averaged to provide the *average median temperature during the night.* The temperatures of the bird during the day and the night are averaged in proportion to the length of these two periods in hours to give the *average median daily temperature.* Table XIV presents averages of these bird temperatures over several consecutive days during the incubation period.

The temperature of a passeriform bird, such as the species listed in Table XIV, averages 107.6° F. (42.0° C.) when it comes on the eggs for an attentive period of incubation. Due to agitation and stirring around while on the nest, the bird's temperature may mount to an average of 108.1° F. (42.3° C.), but falls to an average of 106.5° F. (41.4° C.) when she becomes quiet. Before she leaves the eggs at the end of an attentive period her temperature rises again to an average of 107.2° F. (41.8° C.). Thus, there is a fluctuation of 1.6° F. (0.9° C.) in the bird's temperature during the few minutes when she is on the eggs.

The average temperature of the bird at night is low, 104.6° F. (40.3° C.). This is largely due to the bird's being much less active on the eggs at night than she is during the day, and also because she is without food during this long period. As a consequence, the bird's temperature at night approximates its standard temperature (Table III). Actually it may and it usually does go below what was determined as standard temperature during the day (see graphs of daily rhythm in body temperature, Figures 13-25). This is in harmony with the results obtained by Benedict and Riddle (1929), who found that in pigeons and doves the standard metabolism is nearly 15% lower at night than it is during the day.

The lowest average body temperature given in Table XIV, 105.4° F. (40.8° C.), is for an eastern house wren (No. 3) and the highest, 107.2° F. (41.8° C.), is for an eastern robin (No. 1). This difference amounts to 1.8° F. (1.0° C.), but the difference between the lowest and highest average body temperature of individual house wrens is 1.3° F. (0.7° C.), which is almost as much. The difference between the 2 robin records is 1.2° F. (0.7° C.),

TABLE XIV.—*Body Temperature of Various Passeriform Birds (Females) on the Nest during the Period of Incubation*[1]

Species	Average Initial Temperature of Attentive Periods	Average Highest Temperature of Attentive Periods	Average Lowest Temperature of Attentive Periods	Average Last Temperature of Attentive Periods	Median Temperature of Attentive Periods[2]
Eastern house wren					
(No. 1)....	108.0° F. (42.2° C.)	108.3° F. (42.4° C.)	106.9° F. (41.6° C.)	107.4° F. (41.9° C.)	107.6° F. (42.0° C.)
(No. 2)....	108.0° F. (42.2° C.)	108.7° F. (42.6° C.)	106.8° F. (41.6° C.)	107.8° F. (42.1° C.)	107.8° F. (42.1° C.)
(No. 3)....	107.0° F. (41.7° C.)	107.2° F. (41.8° C.)	105.9° F. (41.1° C.)	106.5° F. (41.4° C.)	106.6° F. (41.4° C.)
Eastern robin					
(No. 1)....	108.4° F. (42.4° C.)	108.8° F. (42.7° C.)	107.2° F. (41.8° C.)	107.8° F. (42.1° C.)	108.0° F. (42.2° C.)
(No. 2)....	107.0° F. (41.7° C.)	107.4° F. (41.9° C.)	106.5° F. (41.4° C.)	107.0° F. (41.7° C.)	107.0° F. (41.7° C.)
Wood thrush	107.1° F. (41.7° C.)	107.2° F. (41.8° C.)	105.5° F. (40.8° C.)	106.1° F. (41.2° C.)	106.5° F. (41.4° C.)
Cedar waxwing...	107.3° F. (41.8° C.)	107.9° F. (42.2° C.)	105.9° F. (41.1° C.)	106.8° F. (41.6° C.)	106.9° F. (41.6° C.)
Catbird					
(No. 1)....	107.8° F. (42.1° C.)	108.0° F. (42.2° C.)	106.4° F. (41.3° C.)	107.0° F. (41.7° C.)	107.2° F. (41.8° C.)
(No. 2)....	106.8° F. (41.6° C.)	107.4° F. (41.9° C.)	105.6° F. (40.9° C.)	106.4° F. (41.3° C.)	106.5° F. (41.4° C.)
Eastern song sparrow	107.6° F. (42.0° C.)	108.2° F. (42.3° C.)	106.8° F. (41.6° C.)	107.4° F. (41.9° C.)	107.5° F. (42.0° C.)
Eastern chipping sparrow	108.5° F. (42.5° C.)	108.8° F. (42.7° C.)	107.7° F. (42.1° C.)	108.3° F. (42.4° C.)	108.3° F. (42.4° C.)
Eastern wood pewee	108.3° F. (42.4° C.)	109.0° F. (42.8° C.)	106.4° F. (41.3° C.)	107.4° F. (41.9° C.)	107.7° F. (42.1° C.)
Grand average...	107.6° F. (42.0° C.)	108.1° F. (42.3° C.)	106.5° F. (41.4° C.)	107.2° F. (41.8° C.)	107.3° F (41.8° C.)

[1]For the dates on which these records were obtained and the number and duration of the periods of attentiveness and inattentiveness, see Table XIII.

[2]The median temperature of the attentive periods is the median of the average highest and the average lowest temperatures of the attentive periods, given in preceding columns.

TABLE XIV (Continued).—*Body Temperature of Various Passeriform Birds (Females) on the Nest during the Period of Incubation*

Species	Median Temperature of Inattentive Periods[3]	Average Median Temperature during Day[4]	Average Median Temperature during Night[5]	Average Median Daily Temperature[6]
Eastern house wren (No. 1)	107.7° F. (42.1° C.)	107.7° F. (42.1° C.)	103.6° F. (39.8° C.)	106.0° F. (41.1° C.)
" " " (No. 2)	107.9° F. (42.2° C.)	107.8° F. (42.1° C.)	105.1° F. (40.6° C.)	106.7° F. (41.5° C.)
" " " (No. 3)	106.8° F. (41.6° C.)	106.7° F. (41.5° C.)	103.7° F. (39.8° C.)	105.4° F. (40.8° C.)
Eastern robin (No. 1)	108.2° F. (42.3° C.)	108.1° F. (42.3° C.)	105.4° F. (40.8° C.)	107.2° F. (41.8° C.)
" " (No. 2)	107.0° F. (41.7° C.)	107.0° F. (41.7° C.)	104.3° F. (40.2° C.)	106.0° F. (41.1° C.)
Wood thrush	106.6° F. (41.4° C.)	106.5° F. (41.4° C.)	103.9° F. (39.9° C.)	105.6° F. (40.9° C.)
Cedar waxwing	107.1° F. (41.7° C.)	106.9° F. (41.6° C.)	104.6° F. (40.3° C.)	105.9° F. (41.1° C.)
Catbird (No. 1)	107.4° F. (41.9° C.)	107.2° F. (41.8° C.)	105.2° F. (40.7° C.)	106.5° F. (41.4° C.)
" (No. 2)	106.6° F. (41.4° C.)	106.5° F. (41.4° C.)	104.8° F. (40.4° C.)	105.9° F. (41.1° C.)
Eastern song sparrow	107.5° F. (42.0° C.)	107.5° F. (42.0° C.)	104.2° F. (40.1° C.)	106.0° F. (41.1° C.)
Eastern chipping sparrow	108.4° F. (42.4° C.)	108.3° F. (42.4° C.)	105.1° F. (40.6° C.)	107.0° F. (41.7° C.)
Eastern wood pewee	107.8° F. (42.1° C.)	107.8° F. (42.1° C.)	105.1° F. (40.6° C.)	106.9° F. (41.6° C.)
Grand average	107.4° F. (41.9° C.)	107.3° F. (41.8° C.)	104.6° F. (40.3° C.)	106.3° F. (41.3° C.)

[3]The median temperature of the inattentive periods is the median of the average last and the average initial temperatures of the attentive periods given in preceding columns, since these are respectively the initial and last temperatures of the inattentive periods.

[4]The average median temperature during the active day is the weighted average of the median temperatures of the attentive and inattentive periods given in preceding columns, combined and averaged in proportion to the length of these periods in minutes. (See Table XIII.)

[5]The average median temperature during the night is the average of median temperatures obtained at fifteen minute intervals.

[6]The average median daily temperature is the weighted average of the bird's temperature during the day and during the night given in preceding columns, combined and averaged in proportion to the length of these periods in hours.

and between the 2 catbird records is 0.6° F. (0.3° C.). From these data the conclusion seems warranted that there is no important difference in body temperature between these species of passeriform birds.

In Table XIV there is given also an average body temperature for 12 individuals of 8 species of passeriform birds. Although the number of birds is small, this figure has, nevertheless, considerable significance. The average temperature during the breeding season maintained within the body of several passeriform species may be stated to be approximately 106.3° F. (41.3° C.). However, passeriform birds must not be thought of as possessing a constant temperature of 106.3° F. (41.3° C.). In fact, the body temperature of a bird is characterized more by its fluctuations than by its constancy. It is proper to say that the temperature of a passeriform bird is a variable, ranging from an average of 104.6° F. (40.3° C.) at night to 107.3° F. (41.8° C.) during the day, with temporary fluctuations both above and below these limits.

Fluctuation in body temperature from day to day.—The question arises as to the amount of fluctuation in the average body temperature of birds from one day to the next, and the possible correlation of these fluctuations with variations in air temperature and activity. The average body temperature over consecutive days of several species of birds was obtained as described on pages 68–69.

Air temperatures were obtained simultaneously with the bird temperatures, not by means of thermocouples, but by use of a Tycos thermograph placed in a small box shelter usually a little below and to the side of the nest box (Plate IV–B). In this position, where it was subjected to nearly identical conditions of sun and wind as was the nest box, it furnished a record approximating closely the exact conditions obtained in the nest, to which the birds were subjected during most of the incubation period. This thermograph records continuously on a chart and needs attention only once a week. Temperature records were taken from this chart once every hour and averaged for all hours of the day and night to give the average daily air temperature.

There is seldom more variation than a few tenths of a degree in the average body temperature of a wild bird from one day to the next (Figure 12). These small variations have significance, how-

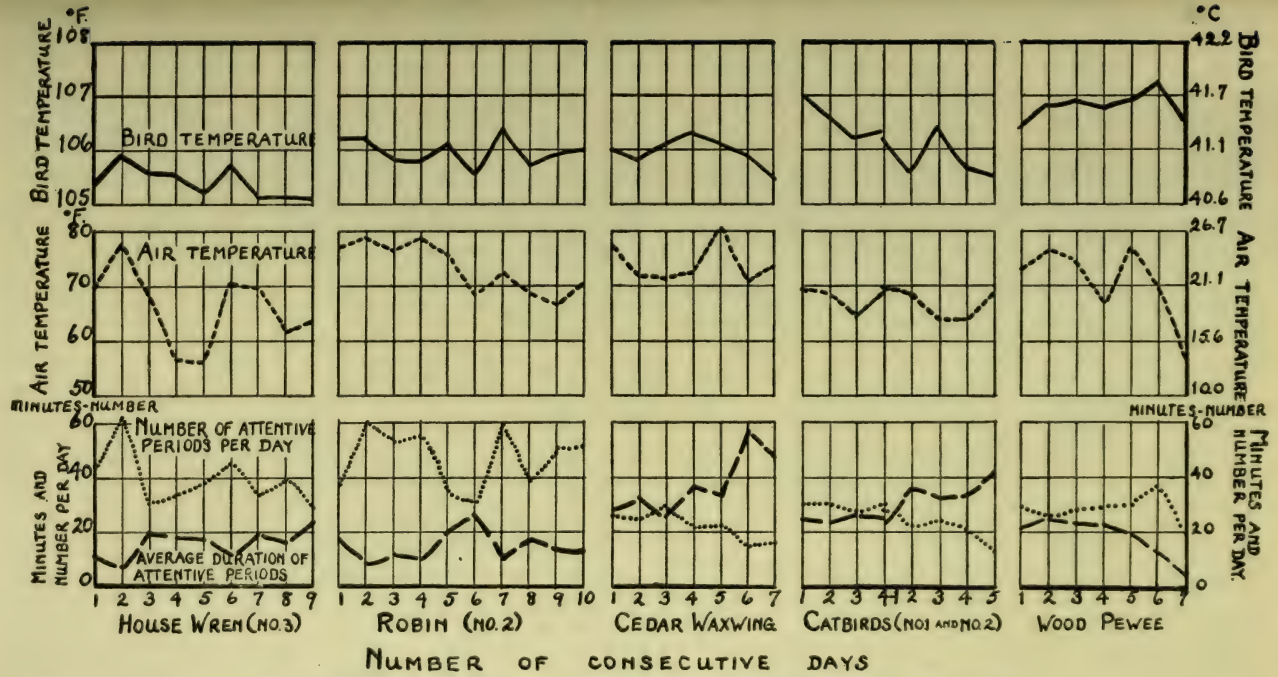


FIGURE 12.—DAILY VARIATION IN BODY TEMPERATURE OF SEVERAL INDIVIDUAL BIRDS OF DIFFERENT SPECIES. These are correlated with variations of air temperature over the same period. The lower set of graphs, indicating number and average duration of attentive periods, is a criterion of the birds' activity.

ever, since they may show some correlation with daily variation in other factors. Records from only those birds where conditions were best controlled are used in this comparison. Although variations as small as these between single temperature records of the potentiometer would fall within the possible error of the instrumental recording and be without significance, these are averages of many records each day and thus not so easily considered errors of recording.

There seems to be some positive correlation (Figure 12) between variations in bird and air temperature in the case of the house wren (No. 3). However, the variation in air temperature amounts to several degrees, while that in the temperature of the bird is only a few tenths of one degree. In the records for the other birds given in Figure 12, slight correlations frequently occur, but they are less evident and not entirely consistent. In part of the catbird record (No. 2), the correlation is inverse. The relation between variations in the average temperature of birds and moderate variations in air temperature from day to day seems to be only very slight.

Any positive correlation that may exist between daily variations in bird and air temperatures must be of either a direct or indirect character. In the experimental work previously discussed (pages 42–45) it was found that slight fluctuations in the air temperature have little or no effect on the bird's temperature, although large fluctuations, occurring within a short time, may produce some temporary variation. Approximately the same amount of direct correlation appears to hold under natural conditions, i. e., the average body temperature of the bird is not greatly affected by variations in air temperature, unless these are extreme.

On the other hand there may be some correlation between bird and air temperature through the effect of variations in air temperature on the bird's activity. The amount of activity of a bird was shown in the experimental work (pages 34–37) to be one of the chief causes for variation in its body temperature. As a measure of the bird's activity, also the number of attentive periods per day and their average duration are plotted in Figure 12.

The number of attentive periods indicates the number of times that the bird goes to and from the nest each day, while the length of the attentive period shows how long she stayed at the nest each

time. The daily variation in the length of the inattentive period is too small to be considered. The more visits that the bird makes to the nest each day, the shorter the time that she stays there on each of the visits. This would be expected, since the length of a bird's day is rather uniform and is controlled more by light and darkness than by temperature. A bird is less active while sitting on the nest than she is while off hunting for food and flying. Therefore, the shorter these attentive periods are and the more numerous, the more active is the bird. A study of Figure 12 indicates that the bird is generally more active on warm days than on cool days. On cool days the bird must be more attentive to incubating the eggs.

The days of greater activity correspond loosely with the days when the bird's temperature is higher, and vice versa. It seems, therefore, that daily variations in the amount of a bird's activities are more important in affecting its body temperature than are variations in air temperature.

The record for the eastern wood pewee in Figure 12 has one point of interest which needs special comment. On the seventh day of recording, the air temperature dropped very low, and considerable rain fell during most of the day. This is correlated with a decided drop in the temperature of the bird and also with a greatly decreased activity and less time on the nest. / This species of bird feeds almost entirely on insects caught in the air. It is probable that the cold, damp weather drove these insects out of the air, so that the bird suffered from lack of food and as a consequence was unable to maintain its previous activity and body temperature. It came to the nest to incubate only 17 times on this day instead of the normal 30 times. After the middle of the afternoon, however, the weather improved, the bird came to the nest more frequently, and its body temperature rose to a high level again.

The question is frequently asked, is there not an increase in the body temperature of the sitting female during the period of incubation? There are no data in our records to indicate such a rise in temperature (Figure 12). Simpson (1911) found no increase in the temperature of a domestic hen during incubation, although he did find that its temperature rose at the time of the hatching of the eggs. The hatching of eggs of passeriform species is a more gradual process with fewer eggs involved than in the case of the

domestic fowl, and in the species that we have studied, no such rise has been noted in the bird's temperature on the days on which the eggs hatched.

No study has been made of seasonal variations in the body temperature of native birds under natural conditions. Sutherland Simpson (1912) carried out an interesting investigation in this connection on the seasonal changes of temperature in the domestic fowl. He took rectal temperatures with mercury thermometers on the same individuals of 6 breeds of chickens every month throughout the year at about the same date and same hour. He found that the bird's body temperature was lowest in December, January, and February, and highest in June, July, and August. He explains the higher temperatures of his birds during the summer as a result of the higher air temperatures, but it seems probable to us that they were due primarily to the greater activity of the birds in the summer, while the higher air temperatures played only a secondary role.

It is probable that the average daily temperature of wild birds, when determined by averaging their body temperatures for all hours of the day and night, is higher in the summer than in the winter. This is not to be explained on the basis of higher summer air temperatures. Rather, it is correlated with a greater amount of activity on the part of the birds during the summer, occasioned by the longer duration of the daily periods of light. As stated above (page 69), the average body temperature of a bird is determined by combining and averaging the temperature of the bird at night, when it is low, and the temperature of the bird during the day, when it is high, in proportion to the length of nighttime and daytime in hours. In northern Ohio, for instance, the daily number of hours of light in the middle of the summer may be over 15, with the number of hours of darkness only 9; while in the middle of winter, the duration of daylight may be only a little more than 9 hours long, while the duration of the night may be nearly 15. This variation in relative length of day and night at different seasons of the year should cause marked seasonal variations in average daily body temperatures of permanently resident birds.

Daily rhythm in body temperature.—Chossat (1843) appears to have been the first to make a serious study of the daily tempera-

ture rhythm in birds. His work has already been cited above (page 40). It was limited to pigeons and doves in confinement. Corin and van Beneden (1887) were the next to work on this problem, their subjects being also pigeons. Their curve shows that the minimum daily temperature comes at 4:00 A. M. and the maximum at 4:00 P. M. The next work done was that of Simpson and Galbraith in 1905. Their study was more extensive and they obtained curves and data on some 12 species of birds. They found that the mean temperature of all species with which they worked was about the same, 105.8°–107.6° F. (41.0°–42.0° C.), but that the mean daily temperature range varied considerably in different species, being greater in smaller birds than in larger, amounting in some cases to over 7° F. (3.9° C.). They conclude that "the temperature curve of diurnal birds is essentially similar to that of man and other homoiothermal mammals, except that the maxima occur earlier in the afternoon and the minima earlier in the morning. In nocturnal birds (owls), on the other hand, the curve is inverted, the maximum occurring about midnight or in the early morning and the minimum about noon or shortly after. As in diurnal birds, the temperature is highest during the natural period of activity (night) and lowest during the period of rest (day)." Riddle, in 1908, obtained a curve showing the daily rhythm of body temperature of 6 ducks, 5 ring doves, and 5 chicks. He found an average variation of 1.3° F. (0.7° C.) between different times of day. The lowest temperatures came between 1:00 and 5:00 o'clock A. M. and the highest about noon. There was a rise in temperature throughout the morning, and a fall throughout the afternoon and evening. Hildén and Stenbäck (1916) secured a generalized composite temperature curve from 6 species of birds obtained principally from zoological gardens, and from which temperature readings were taken every 3 hours by means of a thermometer thrust up the cloaca. The time of minimum temperature in this curve is 9:00 o'clock P. M., and the maximum at noon, with the temperature rising during the morning and falling during the afternoon. In some of their curves for individual birds, there is evident a rapid and pronounced increase of temperature at the beginning of the daylight periods and a similar decrease of temperature at the end. Wetmore (1921) offers a few observations on the daily variations

in wild birds, but his work on this subject is not extensive. Groebbels (1928–b, 1931) in Europe is now working on the daily temperature rhythm of migrating birds.

As discussed above, in the present investigation we have been obtaining nearly continuous records of the body temperature of birds by means of thermocouples placed in the nests and by recording potentiometers. These furnish records both day and night for weeks at a time all through the incubating periods. One particular advantage of this method and of the data obtained is that they are of wild birds under entirely undisturbed and perfectly natural conditions. Records are available for 12 different birds of 8 species over a period of 75 days and nights, including first and second nestings.

To obtain the curves given below (Figures 13–25) for the various hours of the day, 4 temperatures are first transcribed from the potentiometer record for each attentive period. These are the initial, highest, lowest, and last temperatures, which have been discussed in some detail above. The last temperature of one attentive period and the first of the next are averaged to give the median temperature of the bird while away from the nest, and the highest and lowest temperatures of each attentive period are averaged to give the median temperature of the bird while at the nest. The figures thus obtained are then averaged together equally to give the average median body temperature of the bird for each half hour. The time is indicated at each hour and each half hour of the day, but this includes in either case a period from 15 minutes before to 15 minutes after the time stated. At night, median temperatures are recorded directly from the potentiometer chart every 15 minutes. The hourly variations of temperature for each bird were determined for several days and nights. These were then averaged together to get a composite record for each individual. To obtain an average curve for more general application to passeriform species, the records of these 12 birds are averaged together equally (Figure 13). This, of course, is for only the female sex, and can be considered to hold only during the breeding season. The air temperature at the nest was obtained by taking readings from the air thermograph chart every hour and averaging these over the same period of days on which the bird's temperature was recorded.

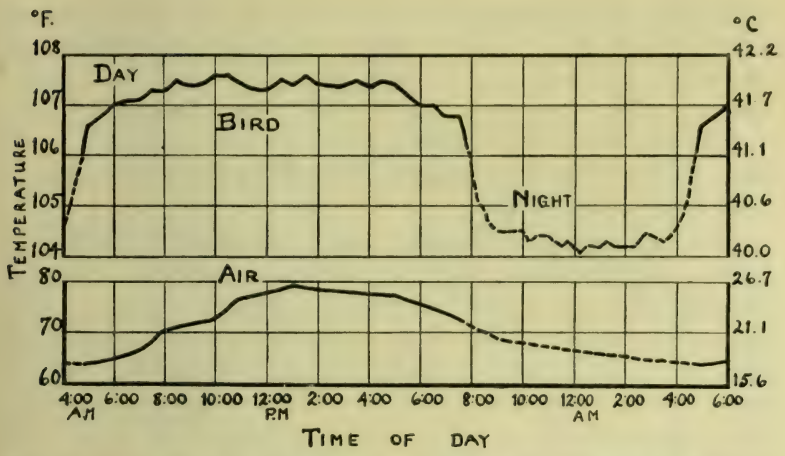


FIGURE 13.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF PASSERIFORM BIRDS. These records comprise 8 species, 12 individuals, and 75 days, correlated with air temperature, and show the effect of activity during the day (continuous line), against the quiet of night (broken line).

It will be easier to understand the normal daily variations in body temperature of birds and the effect of different modifying factors, if there is considered first the curve for the 8 species based on the averages obtained as just described (Figure 13). This composite curve together with a curve showing the daily rhythm in air temperature over the same period are given for comparative purposes in the same figure. It will be recalled that the hours used in this discussion relate to the longitude of Cleveland, Ohio, and are given in Eastern Standard time.

The birds leave the nest in the early morning and commence the daily activities of feeding and incubating at about 4:45 o'clock, as is indicated on the graph. The body temperature then averages about 106° F. (41.1° C.). During the next 5 hours the average increases to 107.6° F. (42.0° C.), which is the maximum average temperature reached by the bird during the day. After that it fluctuates up and down throughout most of the afternoon. From 5:00 o'clock in the afternoon until the end of the day's activity at 7:45 o'clock, there is a pronounced drop of 1.1° F. (0.6° C.).

During the incubating period, the female spends every night on the nest, otherwise the eggs would become greatly cooled. Her

usual time of retirement is shortly after the sun goes down, or about 7:45 P. M. The most rapid drop in body temperature for the whole 24 hour period occurs during the next hour and a quarter. This amounts to 1.8° F. (1.0° C.). From our experimental and observational studies above, we have repeatedly shown that whenever the bird becomes quiet and relaxed physically its body temperature drops.

The bird's temperature does not remain uniform during the night. On the contrary there is considerable variation. The bird does not sleep continuously for long at a time, in fact seldom more than a few minutes. Then it stirs around in the nest, stretches its legs, takes a new position on the eggs, or may entirely leave the nest. On one occasion in our records, we noted that a female house wren left the nest around 8:50 o'clock P. M. after it had retired normally more than an hour before, and did not return until 1:04 A. M. early the next morning. In other instances, the bird has left the nest at night for shorter periods. These cases, however, are exceptional. It is sufficient to note here that the bird is more or less active at night. These activities temporarily raise its temperature and are the cause of some of the fluctuations to be noted.

In previous studies on the temperature rhythm in man and other animals, most authors are accustomed to point out times of rather definite maximum and minimum temperatures. This curve (Figure 13) shows a fluctuating maximum from 10:00 A. M. until 5:00 P. M. The daily maximum air temperature comes at 1:00 P. M. at this time of the year at Cleveland, Ohio.

The night body temperatures reach the lowest point of 104.1° F. (40.1° C.) at 12:15 A. M., but are almost as low continuously until 2:15 A. M. From this time until 3:30 A. M. there is a slight increase of temperature which reaches 104.5° F. (40.3° C.) and then falls back to 104.3° F. (40.2° C.), but this is probably not significant. It is at this time that the bird rests more quietly and for longer periods of time without stirring than at any other time of the day. This can be determined from the potentiometer records, for, of course, as soon as the bird rises off the thermocouple, a drop in the temperature reading is obtained. Also at this time, the bird has been the longest without food, so one would expect for this reason that the temperature would be low. The

air temperature reaches a minimum at about 5:00 A. M. at this time of the year at Cleveland, Ohio.

After 3:30 A. M. until the bird leaves the nest to begin its day's activities at 4:45 A. M., the rise in body temperature is very rapid (1.7° F., [0.9° C.]) and reaches 106.0° F. (41.1° C.). This rapid rise during the hour or so before the bird leaves the box may be the result partly of the bird's becoming more and more uneasy on the nest as the amount of light outside the box is increasing, and partly the result of the bird's becoming more alert mentally and perhaps even more or less excited. The male bird is about and active before the female and frequently comes around the nest, singing lustily, which would arouse the female and tend to increase her body temperature.

In addition to the composite curve for several species above explained, it is worth while to study also the daily temperature rhythm in each individual bird separately. These are shown in Figures 14–25. Each curve is the average of several days' records for the same individual. In general, the individual curves agree with the composite one already considered.

The minimum bird temperature is always reached some little time before the minimum air temperature, usually several hours before. There is a correspondence, however, between the time

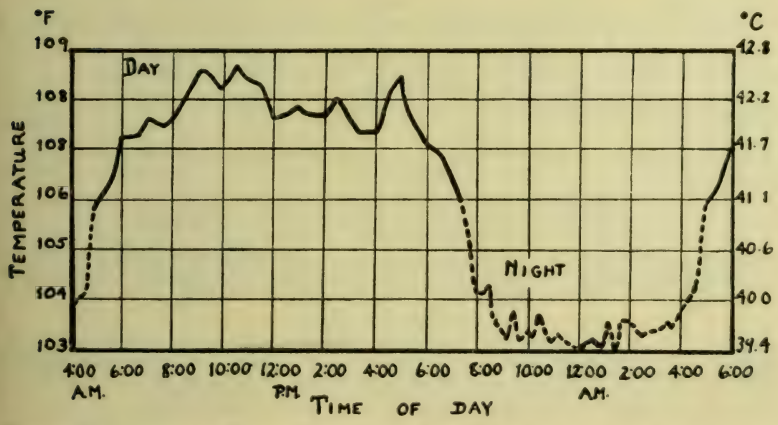


FIGURE 14.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN HOUSE WREN (No. 1). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

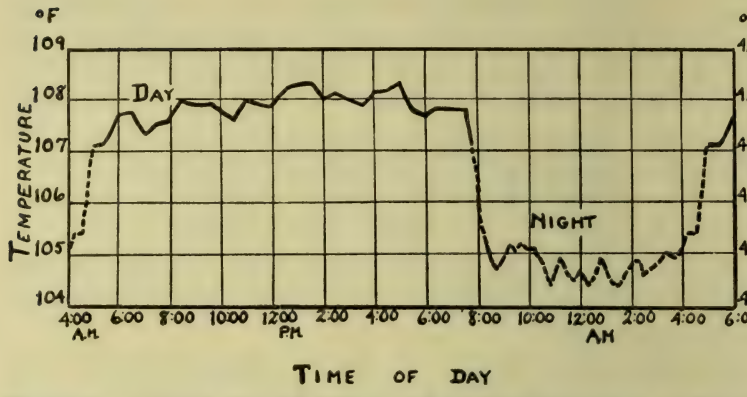


FIGURE 15.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN HOUSE WREN (No. 2). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

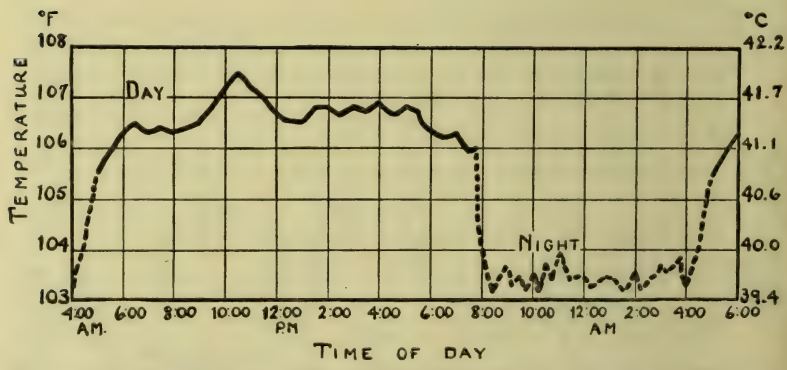


FIGURE 16.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN HOUSE WREN (No. 3). This shows the effect of activity of the day (continuous line) and quiet of the night (broken line).

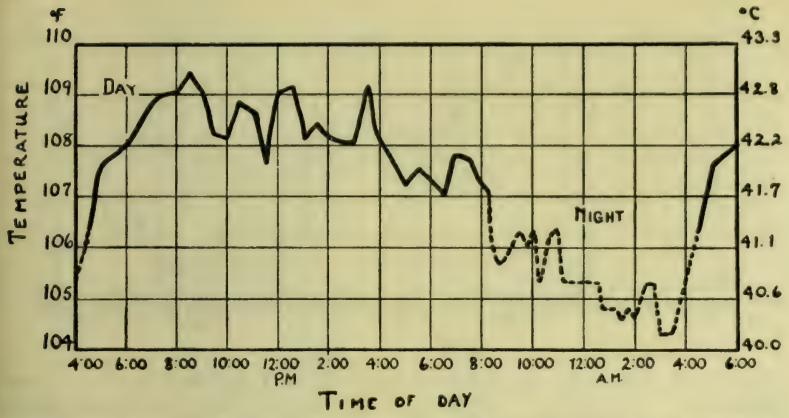


FIGURE 17.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN ROBIN (No. 1). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

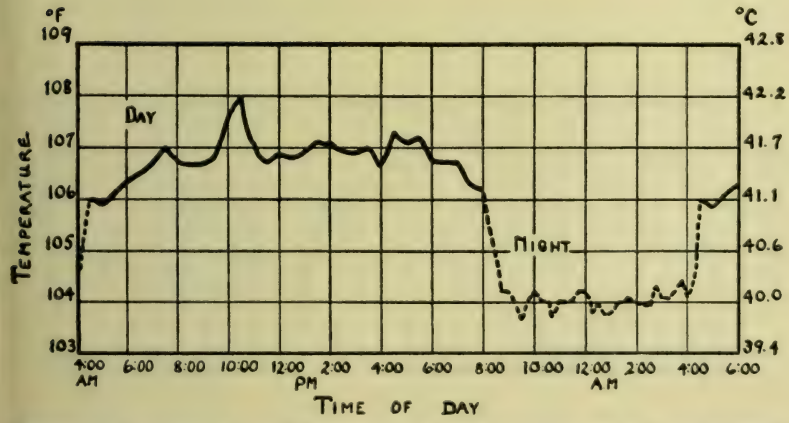


FIGURE 18.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN ROBIN (No. 2). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

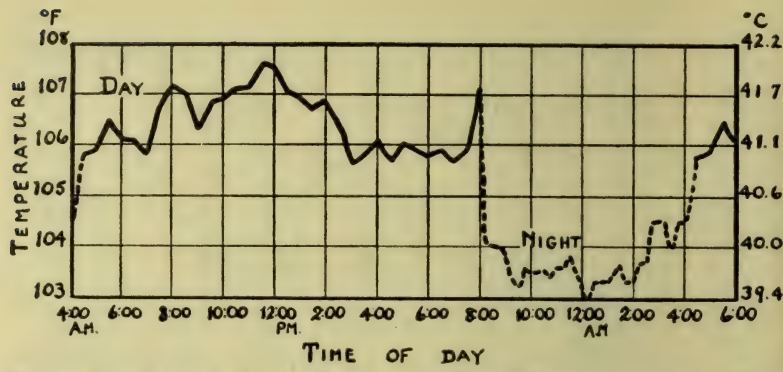


FIGURE 19.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF A WOOD THRUSH. This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

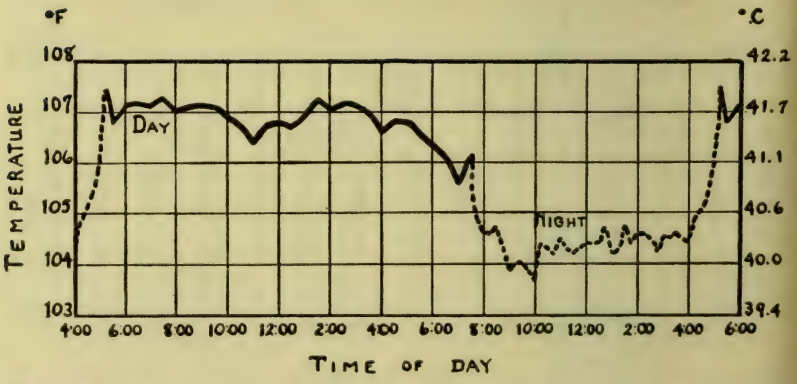


FIGURE 20.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF A CEDAR WAXWING. This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

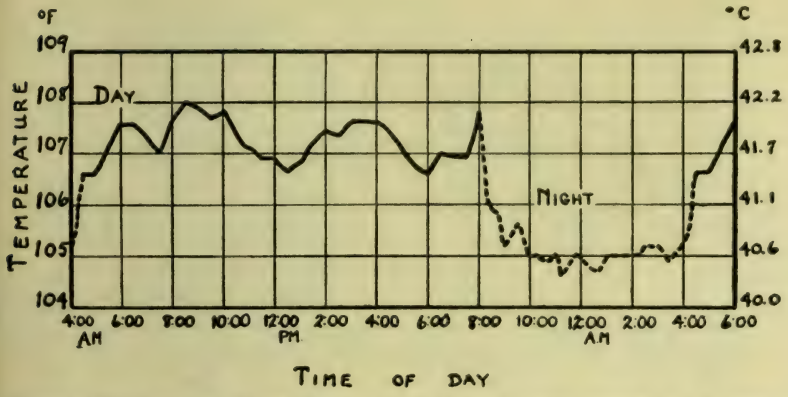


FIGURE 21.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF A CATBIRD (No. 1). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

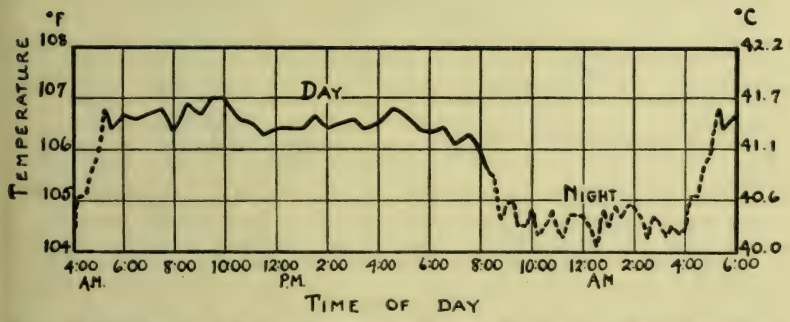


FIGURE 22.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF A CATBIRD (No. 2). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

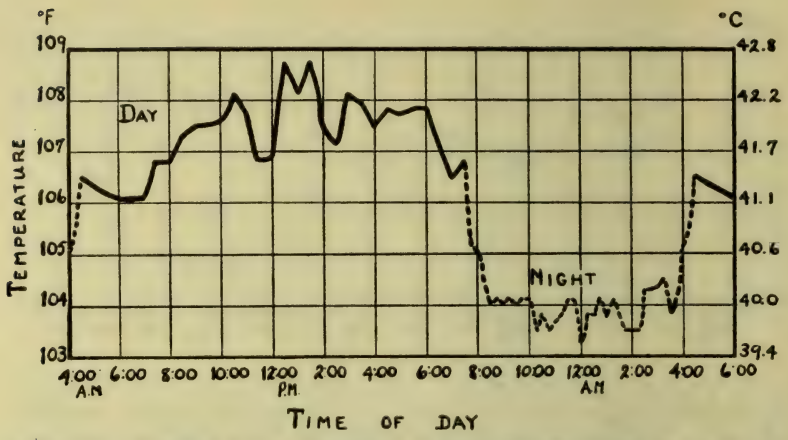


FIGURE 23.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN SONG SPARROW. This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

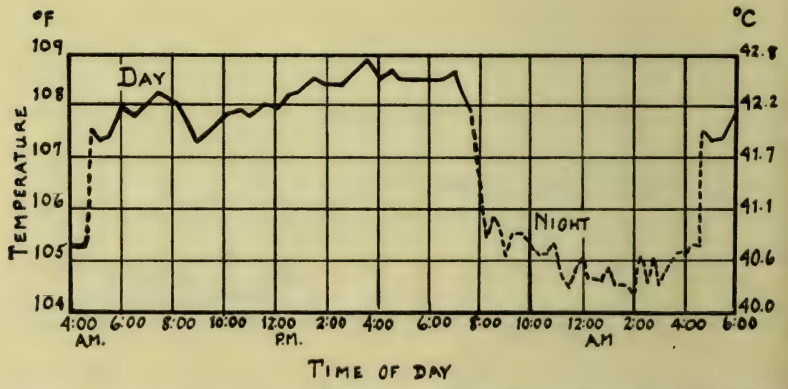


FIGURE 24.—AVERAGE DAILY RHYTHM IN TEMPERATURE OF AN EASTERN CHIPPING SPARROW. This shows the effect of activity during the day (continuous line) and effect of quiet during the night (broken line).

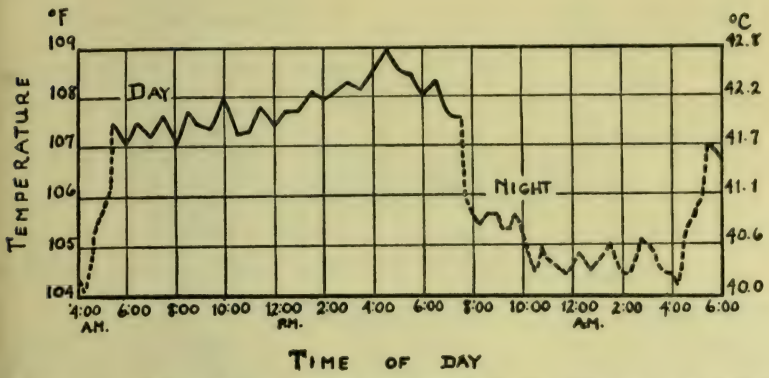


FIGURE 25.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN WOOD PEWEE. This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

that the maximum points in bird and air temperatures are reached, which is usually in the early or middle afternoon. Figure 16 for an eastern house wren and Figure 18 for an eastern robin are of special interest in this respect. The nests of both of these birds were situated on the eastern side of white buildings where they had the full morning sun but were shaded in the afternoon. The result was that the rise in air temperature was very rapid in the morning and quickly reached the maximum for the day. The bird's temperature was very visibly affected, as shown by the sharp peak in the curve at a little after 10:00 A. M. in each case. It was not infrequent for the temperature in the nest to be over 100° F. (37.8° C.) when the adult was absent. Aside from this more or less artificial maximum in the morning, the highest body temperatures for the day were reached in the middle of the afternoon.

The times of day at which the maximum and minimum body temperatures were reached in the different birds are summarized in Table XV.

Both the maximum and minimum temperatures may be reached not just once but several times, or may be approached to within so very few tenths of a degree as to present no significant difference, and these are all noted in Table XV. It is seen that the maximum body temperature may be reached at nearly any time of the day, but not later than 5:30 P. M., and not ordinarily before 8:30 A. M.

TABLE XV.—*Time of Daily Maximum and Minimum Bird Temperatures*

Species	Time of Day Maximum Body Temperature Reached	Time of Day Minimum Body Temperature Reached
Eastern house wren (No. 1)...	9:00–10:30 A. M.; 5:00 P. M.	12:00–1:30 A. M.
" " " (No. 2)...	1:00–1:30 P. M.; 5:00 P. M.	10:45 P. M.; 12:15 A. M.; 1:15–1:30 A. M.
" " " (No. 3)...	10:30 A. M.; 1:30–5:00 P. M.	8:30–10:15 P. M.; 12:15 A. M.; 1:30 A. M.; 2:15 A. M.
Eastern robin (No. 1).....	8:30 A. M.; 12:30 P. M.; 3:30 P. M.	3:00–3:30 A. M.
" " (No. 2).....	10:30 A. M.; 4:30–5:30 P. M.	9:30 P. M.; 10:45 P. M.; 12:15–1:00 A. M.
Wood thrush.....	11:30 A. M.–12:00 Noon	12:15 A. M.
Cedar waxwing.....	5:15 A. M.; 7:30 A. M.; 1:30 P. M.....	9:00–10:00 P. M.
Catbird (No. 1).....	8:30–10:00 A. M.	11:15 P. M.; 12:45 A. M.
" (No. 2).....	9:30–10:00 A. M.	12:30 A. M.
Eastern song sparrow.....	12:30–1:30 P. M.	10:15 P. M.; 10:45 P. M.; 12:00 P. M.; 1:45 A. M.; 2:15 A. M.
Eastern chipping sparrow.....	3:30 P. M.....	2:00 A. M.
Eastern wood pewee.....	4:30 P. M.....	4:15 A. M.

Early afternoon seems to be the most characteristic of any single time.

Likewise, the daily minimum body temperature may come at nearly any time between 8:30 P. M. and 4:15 A. M., although it comes most frequently around midnight. The chief value of this table is that it indicates to some degree the flexibility and variability of the bird's body temperature.

The question arises next as to the extent of this daily fluctuation in bird temperature. Table XVI was prepared from the highest mean body temperature during any half hour of the day and the lowest mean body temperature from any 15 minute period during the night regardless of the time at which such temperatures occurred. These maximum and minimum temperatures of each day were averaged then for each individual for the whole period of observation.

From Table XVI it is seen that the average daily range in the bird's temperature amounts to 5.3° F. (3.0° C.). This is very close to the true range, while 108.7° F. (42.6° C.) and 103.4° F. (39.7° C.) are very nearly the true extremes that the body temperature reaches daily. These temperatures do not, however, represent the greatest temporary extremes to which the body temperature may go. The daily maximum temperatures given are for half-hour periods determined in the manner above explained

TABLE XVI.—*Daily Extremes and Range in Temperature of Female Birds on the Nest during Incubation Period*

Species	Number of Days' Record	Average Daily Maximum Temperature	Average Daily Minimum Temperature	Average Daily Range in Bird Temperature	Average Daily Range in Air Temperature at Nest
Eastern house wren (No. 1)	8	109.4° F. (43.0° C.)	102.5° F. (39.2° C.)	6.9° F. (3.9° C.)	29.6° F. (16.6° C.)
" " " (No. 2)	13	109.5° F. (43.1° C.)	104.0° F. (40.0° C.)	5.5° F. (3.1° C.)	19.7° F. (11.0° C.)
" " " (No. 3)	9	108.0° F. (42.2° C.)	102.5° F. (39.2° C.)	5.5° F. (3.1° C.)	25.3° F. (14.2° C.)
Eastern robin (No. 1)	2	109.6° F. (43.1° C.)	104.3° F. (40.2° C.)	5.3° F. (3.0° C.)	22.0° F. (12.3° C.)
" " (No. 2)	10	108.6° F. (42.6° C.)	102.8° F. (39.3° C.)	5.8° F. (3.2° C.)	17.3° F. (9.7° C.)
Wood thrush	3	107.8° F. (42.1° C.)	102.5° F. (39.2° C.)	5.3° F. (3.0° C.)	13.3° F. (7.4° C.)
Cedar waxwing	7	107.8° F. (42.1° C.)	103.2° F. (39.6° C.)	4.6° F. (2.6° C.)	17.0° F. (9.5° C.)
Catbird (No. 1)	4	108.5° F. (42.5° C.)	104.2° F. (40.1° C.)	4.3° F. (2.4° C.)	17.2° F. (9.6° C.)
" (No. 2)	5	107.7° F. (42.1° C.)	103.8° F. (39.9° C.)	3.9° F. (2.2° C.)	14.8° F. (8.3° C.)
Eastern song sparrow	2	109.3° F. (43.0° C.)	104.3° F. (40.2° C.)	5.0° F. (2.8° C.)	16.5° F. (9.2° C.)
Eastern chipping sparrow	3	109.2° F. (42.9° C.)	103.6° F. (39.8° C.)	5.6° F. (3.1° C.)	15.0° F. (8.4° C.)
Eastern wood pewee	9	109.3° F. (43.0° C.)	103.2° F. (39.6° C.)	6.1° F. (3.4° C.)	15.9° F. (8.9° C.)
Grand average	(75 days)	108.7° F. (42.6° C.)	103.4° F. (39.7° C.)	5.3° F. (3.0° C.)	18.6° F. (10.4° C.)

(page 78). During this half-hour period of highest *average* temperature during the day, the bird's temperature may go considerably higher for short periods from excitement or unusually great exertion (pages 34–37). Temperatures as high as 112.3° F. (44.6° C.) have been recorded of an eastern robin on the nest, and similar high temperatures are not uncommon for other species. The minimum temperature of 103.4° F. (39.7° C.) is about the lowest ordinarily reached, although, in a few instances, a minimum temperature of 102.0° F. (38.9° C.) has been obtained. An extreme variation in body temperature for different hours of the day amounting to over 10° F. (5.6° C.) may be expected under certain conditions. The fluctuations in bird temperature are dependent largely upon activity, as explained above (pages 34–37), and not primarily on the range in air temperature. However, in Table XVI the greatest range in a bird's temperature is correlated indirectly with the greatest range in air temperature (eastern house wren No. 1), while the least range in a bird's temperature is correlated with the next to the least range in air temperature (catbird No. 2).

The cause for a daily rhythm in body temperature is complex. It is shown by experimental work that activity raises a bird's temperature and that inactivity lowers it. That this is of primary importance in the natural daily rhythm of temperature cannot be questioned. This is particularly evident from the very rapid increase in body temperature that takes place with the beginning of activities early in the morning, and the correspondingly rapid decrease in the evening when this activity ceases for the day. We know also that the digestion of food stimulates metabolism and heat production in the body tissues and affects the bird's temperature. This stimulating influence would be felt more during the daytime than at night. The standard metabolism is probably lower at night than during the day (Benedict and Riddle, 1929). The fluctuation in air temperature may be important indirectly by modifying activity. When air temperature becomes extreme it may have a direct importance. The maximum bird's temperature comes at about the time of the maximum air temperature. The minimum bird's temperature, however, comes several hours before the minimum temperature of the air. Mental activity and excitement during the day increase the functional and muscular activities

of the body, which in turn may raise the body temperature. At night, the bird is at rest, quiet, and more or less asleep, so that these functional and muscular activities are at the minimum. All these factors are of importance, then, in producing this daily rhythm of body temperature. In addition, other internal physiological processes in the body may vary rhythmically and be involved, but these have not been measured.

Experimental control and reversal of daily temperature rhythm.—If activity is one of the chief factors in influencing bird temperatures, and light the chief controlling factor in regulating bird activities in nature, then by reversing and controlling the light period of the day, the bird's temperature should vary accordingly.

Simpson and Galbraith (1905) showed that in owls which are normally active at night and inactive during the day, the temperature rhythm is just the reverse of that in diurnal birds. The most extensive experimental work on reversal of the normal temperature rhythm in birds has been done by Hildén and Stenbäck (1916), already quoted above. After they obtained a set of curves showing the normal daily temperature variation, they reversed the periods of activity. During the day, from 6:00 A. M. to 6:00 P. M., they kept the birds in the dark. From 6:00 to 9:00 P. M. and from 3:00 to 6:00 A. M., the birds were kept in weak light to simulate dusk and dawn, while from 9:00 P. M. to 3:00 A. M. the birds were in bright light. They found that there was a complete reversal in the daily rhythm, so that the maximum body temperature now came during the night (light period) and the minimum temperature during the day (dark period). When the birds were replaced in normal conditions of lightness and darkness, the temperature rhythm returned in a very few days to the normal mode of variation. This was irrespective of variations in air temperature.

Our own experiments in reversal of the daily temperature rhythm in birds have been rather limited, but have produced something in the way of results which indicate that the temperature rhythm of birds captured in the wild state may be artificially reversed in much the same manner as in the caged birds worked with by Hildén and Stenbäck. Eastern chipping sparrows, English sparrows, and eastern song sparrows were used in this

work. Several attempts were made to change the activities of many individuals, by subjecting them to light from electric bulbs at night and to darkness during the day. For some reason, the birds in most cases died, although some, at least, had been kept under caged conditions in good health for several days previous to the experiment. The reason for their dying may possibly have been a too precipitous reversal of the normal periods of activity. However, in at least four experiments, significant results were obtained, of which one is shown in Figure 26. During the experiment a female eastern chipping sparrow was confined in a small cage and kept supplied with food, which was freely eaten, and with water. The first control record obtained (Figure 21 [1]) by means of the indicator potentiometer and a thermocouple down the throat, between 10:16 and 10:56 in the morning, shows the normal tem-

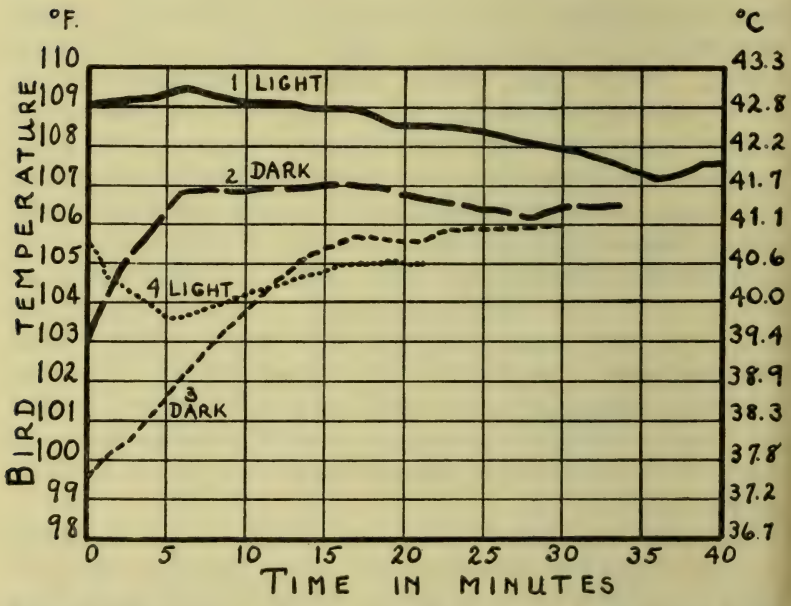


FIGURE 26.—REVERSAL OF DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN CHIPPING SPARROW, BY CONTROLLING THE PERIODS OF LIGHT AND DARKNESS. 1—Control; Temperature of bird during normal day period, 10:16–10:56 A. M. 2—Control: Temperature of bird during normal night period, 11:27–12:00 P. M. 3—Reversal: Temperature of bird confined in dark during the day, 11:06–11:36 A. M. 4—Reversal: Temperature of bird kept in light during the night, 10:18–10:39 P. M.

perature of the bird during the day. The second record obtained, between 11:27 and 12:00 P. M., gives the corresponding control at night (Figure 26 [2]). Then during the next 4 days, conditions were gradually changed until the bird was in the light at night, commencing at about 6:15 P. M., and in the dark during the day, beginning at 7:45 A. M. The normal daily rhythm in air temperature was not interfered with and so does not explain the results obtained. A record of the bird's temperature was then taken from 11:06 to 11:36 A. M. when it had been in the dark (Figure 26 [3]). The first temperature of the bird obtained at this time was 99.3° F. (37.4° C.), which is very low and shows the effect of inactivity. However, the body temperature of the bird rose to nearly 106° F. (41.1° C.) during the next half hour, a result produced by excitement and exertion when its temperature was being taken. At 10:18 that evening, the bird's temperature was again taken after it had been active in artificially produced light. The first temperature of the bird obtained at this time was 105.3° F. (40.7° C.) (Figure 26 [4]). The first records of the temperature of the bird obtained are, in the case of these experiments, the most significant, as they show the immediate effect of the light and dark periods on the activity of the bird. Although the experimental results are much lower than the control records, the temperature of the bird after being in the dark was in each instance (Figure 26 [2 and 3]) lower than it was after being in the light (Figure 26 [1 and 4]), although in the second case (Figure 26 [3]) the dark period came at midday, rather than at midnight as in the control (Figure 26 [2]). The three other successful experiments support these results. Thus, these experiments substantiate the results obtained by Hildén and Stenbäck, in that by controlling and reversing the periods of activity, the rhythm of body temperature may be controlled and reversed.

Various anaesthetics will exert a profoundly quieting effect on the activities of birds, and render them more or less motionless for long periods of time. James Stevenson, in this laboratory, has studied the effect of urethane upon the body temperatures of starlings—and one of his figures is reproduced here (Figure 27). The urethane was dissolved in distilled water and introduced into the stomach. One hundred and fifty milligrams were first given to the bird to put it into anaesthesia, and 50 milligrams were

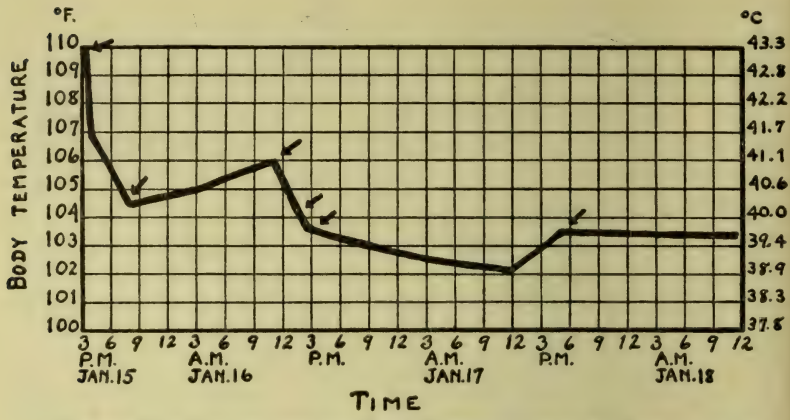


FIGURE 27.—FLUCTUATION IN BODY TEMPERATURE OF A STARLING IN ANAESTHESIA. Arrows indicate times at which the anaesthetic was given.

given at repeated intervals thereafter. Temperatures were taken intermittently by means of a thermocouple put down the throat. The room temperature fluctuated slightly around 72° F. (22.2° C.).

Figure 27 shows that the body temperature falls rapidly at first, but that after a time it becomes more or less constant. The normal daily temperature rhythm is destroyed (compare with Figure 13), the body temperature becomes profoundly lowered although the air temperature is constant, and such minor fluctuations in body temperature as do occur are due to the bird's temporarily coming partway out of anaesthesia. This again substantiates the idea that it is muscular activity which is mainly responsible for causing the regular daily rhythm in body temperature.

MECHANISM OF TEMPERATURE CONTROL

Much has been written concerning the mechanism of temperature control in warm-blooded animals, particularly in mammals, and every text-book of physiology devotes several pages to the discussion of this important subject. (For particularly good accounts see Edwards, 1839; Gavarret, 1855; Pembrey, 1898; Hill, 1906; Pütter, 1911; Lusk, 1921; Barbour, 1921; Starling, 1926; and Bazett, 1927.) Less is known concerning temperature regulation

in birds than in mammals, and, in fact, the exact mechanism is still uncertain. It is desirable here to bring together the latest information on the subject and to offer some suggestions based on the results of our own investigations.

Two factors are involved in determining the temperature of any animal—heat production and heat loss. In many homoiothermal animals, particularly mammals, the balance between the two is maintained approximately constant, so that the "Eigenwärme" is nearly the same under all conditions of the environment. Variations in the body temperature may be caused by changes in either the heat production or the heat loss. The proper maintenance of a balance between the two is the function partly of the nervous system, and partly, as we shall show later, of the endocrine or ductless glands. The body temperature of birds is unique because it is so variable, much more so than in many mammals, notably man.

Most of the general metabolic processes in the body tissues are exothermic in that some of the energy is lost or liberated in the form of heat. Metabolism in muscular tissues is probably the most important single factor in the production of heat. Heat is liberated in great amounts when the muscle contracts, both during the contraction and recovery phases. Muscular activities of various sorts are therefore responsible for a considerable amount of heat production. Unless there is a corresponding increase in heat loss there is a rise in the body temperature. Even when at rest, striated muscle is more or less contracted and so is continually liberating heat. When the body temperature of mammals becomes reduced, shivering may occur. This is more or less involuntary, and must be considered as a factor in temperature regulation since it increases heat production. Shivering occurs also in birds. The beating of the heart is a continual source of some heat to the body. Heat is, likewise, produced by the muscular movements involved in respiration.

It has been shown by Rubner and others that food stimulates metabolism. The heat value of one gram of protein is 4.1 large calories, of one gram of carbohydrate 4.1 large calories, and of one gram of fat 9.3 large calories. The carbohydrates are particularly important in heat production because they are readily available and easily oxidized. The activities of the different

glands of the body are probably also sources of heat production because of the chemical changes occurring in them.

Benedict and Riddle (1929) have shown that starvation lowers the metabolism in birds very markedly. This agrees with our finding that the body temperature decreases when the birds are deprived of food. The body temperature of the bird is dependent on the heat produced during general metabolism, therefore a marked reduction in the heat produced brings about a lowering of body temperature.

The effect of air temperature in stimulating or depressing metabolism and heat production in the bodies of animals has been known many years. Voit in 1904 (Lusk, 1921) found that the heat production of a pigeon is doubled after removing its feathers. Low air temperatures stimulate heat production, which is usually entirely compensated for by regulation of the rate of heat loss, so that the balance between heat produced and heat lost is maintained. High air temperatures that are not extreme act in the opposite manner by depressing the metabolism, while heat loss must be correspondingly changed if the body temperature is to remain constant. That air temperatures do affect heat production in birds to a remarkable degree is shown in recent experiments by Riddle, Christman, and Benedict (1930) on ring doves. Here it was found that there was a reduction in the metabolism of male birds at 86° F. (30.0° C.) of 28.1 per cent of what it was at 68° F. (20.0° C.), while in females, the reduction was 20.3 per cent. Groebbels (1920) has also done extensive work on the metabolism of birds in relation to air temperatures and with similar results.

The influence of the nervous system in the regulation of heat production has been generally realized, and there have been attempts to locate in mammals a temperature regulating center in the corpus striatum of the brain. This may be effective through a regulation of the increase or decrease of physical activities in cold or hot weather, through regulating the amount and kinds of food consumed, or by modifying the tone and metabolism in muscle and body tissues. This is usually considered "chemical regulation."

That the endocrine glands may play a role in chemical regulation of body temperature has become generally appreciated only during the last few years. Various investigators have, however, pretty

well established the fact that at least certain of the endocrine organs, particularly the thyroids and adrenals, are important in regulating the metabolism of the body and thereby regulating the body temperature (Cramer and McCall, 1916; Cramer, 1916, 1918; Cannon, Querido, Britton, and Bright, 1927). The thyroid gland undergoes marked fluctuations in activity, and this is correlated inversely with air temperature (Cramer, 1916; Mills, 1918; Cramer and Ludford, 1926; Riddle and Fisher, 1925). In the work of Riddle and Fisher (1925), "three kinds or species of pigeons were kept on the same diet throughout the year and killed during all months of a three-year period. The weights of the thyroids from these three species indicate a nearly simultaneous enlargement in autumn and winter months and a progressive decrease in size during the months of spring and summer. These size changes promptly follow the onset of a colder autumn and warmer vernal temperatures. Promptness of change, rather than evident delay, is indicated by practically all the data obtained. This seasonal enlargement of the thyroid is probably associated with seasonal increase of the thyroid function and increased heat production." Bergtold (1926) calls attention to the fact that the same relation and seasonal variation have been found in the crow.

Cassidy, Dworkin, and Finney (1926) describe a relation between insulin, blood sugar, and body temperature, which may be of importance in normal regulation of body heat.

With regard to the regulation of heat loss from the body, the feathers with which birds are covered form an excellent insulating wrap. Loss of heat by radiation and conduction is, therefore, greatly handicapped in birds as compared with man and some other mammals. Birds do not possess sweat glands, hence this means of cooling the body cannot be considered. Insensible perspiration in animals without sweat glands is sometimes considerable (Bazett, 1927). The feathers and the dead air space which they include are better adapted to conserve heat than to dissipate it, so there can be only a small percentage of loss from the general surface of the body. In man, much heat is lost from the skin in warm weather when the arterioles enlarge and bring more blood into this region. In cold weather these arterioles contract, so heat is saved. From the data on skin temperatures of birds presented herein, there is some evidence that the temperature of the skin is lower,

relative to the temperature of the body, when the body temperature is high than when it is low. This would argue that the blood vessels do not become expanded when the body temperature rises, and that there is very little loss of heat through the feathers.

Experiments of taking the temperature of birds before and after the removal of the feathers have been performed. Edwards (1839) was the first to do this. He minimizes the importance of feathers in temperature regulation. "An adult sparrow which has had all its feathers clipped off does not at first suffer loss of temperature to the extent of more than a degree, and by-and-by recovers even this; . . ." Our own work does not entirely confirm this statement. Temperatures were taken of a juvenal English sparrow in a basement room when the air temperature averaged 70° F. (21.1° C.). The bird maintained a temperature around 106.7° F. (41.5° C.) for some time. The feathers were then clipped off and the bird's temperature again taken. This time the bird had a temperature of 104.0° F. (40.0° C.) and this it maintained for nearly half an hour—probably through increased heat production. Then, however, its body temperature dropped to 88.8° F. (31.6° C.), when the experiment terminated.

Another experiment performed with 3 juvenal English sparrows consisted in determining the length of time during which they could resist air temperatures with and without feathers. Two of the birds were placed at a constant temperature of 40° F. (4.4° C.) in a refrigerator, one with feathers in normal condition to act as a control, the other with all feathers cut off with shears. The third bird, also without feathers, was placed in a small incubator at 99° F. (37.2° C.). The control bird at 40° F. (4.4° C.) and the defeathered bird at 99° F. (37.2° C.) each lived about 12 hours, but the bird placed at 40° F. (4.4° C.) without feathers died within 4.5 hours. Clipping off the feathers reduced the survival time, therefore, to little more than a third of normal, due probably to the more rapid heat loss and wasting of reserves through increased metabolism. The clipped bird at 99° F. (37.2° C.) survived longer because the high air temperature compensated for the lack of feather covering. All of these birds were without food.

The fluffing out of the body feathers to increase the thickness of the insulating coat and the amount of non-conductive air contained therein is another device for cutting down the rate and

amount of heat lost from the body. Birds are frequently seen in nature with feathers fluffed out in this manner, particularly during cold weather (Allen, 1925, page 36), and this is a rather common habit of roosting birds on cool nights.

In the course of the experimental work reported in the first part of this paper (pages 47–50), it was found that the temperature of the eastern house wren confined closely in a small sack made of mosquito netting fell more or less rapidly below normal when the bird was subjected to low air temperature. This fall or break in the bird's temperature regulation began, on the average, when the air temperature fell to 50° F. (10.0° C.). This does not mean that this species of bird is unable to withstand such air temperatures in nature, because we have proved elsewhere in work to be reported in a future paper (Kendeigh) that the eastern house wren will withstand even lower temperatures for several hours, provided it is not confined too closely but is allowed some little freedom, particularly enough to allow it to fluff out its feathers. Observations on this species indicate that the feathers are not fluffed out until some low degree of temperature is reached. It seems, therefore, that the break in the bird's temperature regulation at 50° F. (10.0° C.) was due, in part, to the bird's being prevented from fluffing out its feathers, which would naturally have taken place when the air temperature reached this degree. Since the probable error of this mean temperature for the 16 birds experimented on is only $\pm 2.9°$ F. (1.6° C.), this temperature must represent a definite time or degree at which the act of fluffing out the bird's feathers takes place, and signifies that this act is an important one in the general mechanism of temperature regulation.

Feathers undoubtedly have an important place in regulation of temperature. Their function is primarily to conserve rather than to dissipate body heat. Therefore, they are of considerable importance to the bird in the winter. In summer they probably protect the bird considerably from the direct heat radiation of the sun, which would otherwise produce an overheating of the body and consequent death (page 121). The molting season in many species occurs during late July and August, the hottest part of the year, and all the feathers are renewed before the cold season begins.

The pigmentation of the feathers may have an importance in temperature regulation which has not been appreciated. The

absorption, transmission, or reflection of the sun's rays by different pigments may be of vital concern to the bird aside from the color effects produced. Cartwright and Harrold (1925) and Hadwen (1926) have discussed this subject, but much experimental work needs yet to be done before definite judgment can be pronounced.

In individuals and species of different size among the mammals, body size is considered important. The proportionate amount of the body surface decreases as the body bulk increases. Therefore, there must be a higher heat production per unit of weight in small animals than in larger to compensate for the greater heat loss. There is some evidence that size is an important factor among different species of birds, since Regnault and Reiset (Lusk, 1921, page 120) found that the heat production in sparrows per unit weight was ten times greater than in fowls.

The warming of ingested food to body temperature and the loss of heat in the excreta is an important source of heat loss, considering the rapid rate at which food passes through the alimentary tract in birds.

When, in the course of evolution, the body became covered with feathers, the bird lost the most important area for the dissipation of the heat metabolism. This had to be compensated for in some way, and it appears to have been accomplished through the expansion of the respiratory system into all parts of the body in the form of air-sacs. True air-sacs occur only in birds, although, according to Heilmann (1926), they have their prototype in the reptilian lung.

The air-sacs in the pigeon have been described in detail by Müller (1908). There are 5 main groups, as follows: *sacci abdominales* in the abdominal region; *sacci intermedii posteriores* and *sacci intermedii anteriores* in the thoracic cavity; *saccus interclavicularis,* proximal to the syrinx in the thorax; and *sacci cervicales* in the region of the nape of the neck. All of these are pairs except the interclavicular, and this is really the result of a fusion in the course of development. These air-sacs are connected directly with the bronchi, and are really enlargements of the bronchi that have emerged from the surface of the lung and penetrated between the organs of the body. They have thus direct communication with the outside air through the bronchi, syrinx, trachea, larynx, and buccal-pharyngeal cavity. The size of the

air-sacs as hollow vesicles varies with the respiration and the inspiration and expiration of air. Smaller diverticula diverge from these larger sacs and ramify to various parts of the body and into the hollow cavities of the bones. The walls of the air-sacs are thin but elastic and contain very few blood vessels, except within the bones where they are plentifully supplied. The ostia, or the openings from the bronchi of the lungs into the air-sacs, are large and conspicuous. The presence of both radial and oblique muscle fibers forming a sphincter around these ostia was formerly suspected, but could not be verified by Müller. These air-sacs thus form a hollow air system penetrating to nearly all parts of the bird's body in a manner comparable to the tracheal system in insects.

Locy and Larsell (1916) have studied in some detail the development of air-sacs in the chicken. They find that between the seventh and ninth days of incubation the air-sacs emerge and on the ninth day project beyond the lung. From the account of these authors, the air-sacs are apparently fully developed by the end of the first day after hatching, although they very probably increase in size with the growth of the chick. The lung of the chick becomes functional as an organ of respiration shortly before hatching, and there is every reason to believe that the air-sacs may begin to function at about the same time.

Locy and Larsell (1916) have made an important advance in the understanding of the function of the air-sacs by their study of "recurrent bronchi." In the course of embryonic development, the air-sacs are formed as terminal expansions of secondary or tertiary branches of the bronchial tree. The air-sacs then form outgrowths which reenter the lungs as recurrent bronchi and connect with other branches of the main bronchial tree. The recurrent bronchi have their openings from the air-sacs very close to the point where the incurrent bronchi enter. By their anastomosing with other branches they are brought into communication with all parts of the lung. The air-sacs then are not dead air spaces, but a circulation of air is possible from the main bronchi into the air-sacs and back into the lung and main bronchi through the recurrent bronchi.

Much has been written concerning the air-sacs in birds, and many theories have been formulated concerning their possible

physiological function, yet very little is actually known about them in different species of birds. The most important theories regarding their use to the bird are that they aid respiration, that they lighten the bird and so facilitate flying, and that they serve for temperature regulation of the body. It is possible and indeed probable that the air-sacs serve all three purposes, so that there need be no conflict between the advocates of each idea. It is our purpose here to discuss only the role of the air-sacs in temperature regulation.

Wetmore (1921) discusses in a general way the manner in which the air-sacs may function in regulating temperature, although he was not the first to propound the theory. The manner in which the system of air tubes penetrates between the heat-forming organs all over the body, the way they approximately parallel the main blood channels, and enter into the middle of some of the thickest groups of muscles by means of bones, makes them appear very well adapted indeed to care for the heat generated by these tissues. The presence of recurrent bronchi also makes possible a circulation of air in air-sacs with each respiratory movement, which may take care of a considerable amount of heat. It has been assumed that at low air temperature the movement of air in and out of the air-sacs may be less than when the air temperature is high. In this way the body may be kept warm at low air temperatures and cooled at higher air temperatures.

Just how this ventilation of the air-sacs may be regulated is not known. However, if recurrent bronchi are of general occurrence in the class of birds, and if the circulation is complete as indicated, then there is an apparatus at hand in the recurrent bronchi themselves to regulate this passage of air through the sacs. In mammals, the bronchioles of the lung are surrounded by plain muscle which is maintained in a state of tone by a branch of the vagus nerve. The nerve contains both bronchioconstrictor and bronchiodilator fibers. A secretion of the adrenal glands also affects the contraction of the bronchioles. In birds, the same arrangement and innervation may be assumed, and it would not be impossible that the walls of the recurrent bronchi or the bronchioles may be capable of considerable contraction or dilation. In this way the passage of air through the sacs could be controlled—reflexly over the

nervous system—with the stimulus being temperatures either above or below normal.

Not only would the internal parts of the body be cooled through the radiation of heat into the air-sacs from the surrounding muscles, glands, and blood vessels, but the evaporation here of water could be also an important item. Hári (1917), experimenting with geese, found that of the total heat lost by birds at 81° F. (27.2° C.), 50.5% was lost by evaporation of water; but at 61° F. (16.1° C.) only 20% was lost in this way. This shows, as one would expect, greater evaporation of water from the body at higher temperatures, probably through the air-sacs.

Much work needs to be done on this problem of bird respiration, and some interesting findings very probably await the investigator who has the patience and technique for undertaking this research. In this connection, the experiments of Victorow (1909) need to be mentioned. Working with doves, he first made an anatomical study of their air-sacs, and then attempted to determine their role in cooling the body. He etherized his birds and mechanically destroyed the functioning of the air-sacs. He then tetanized the flight muscles by means of an electric induction current. This produced a rise of temperature within a short time of respectively 4.7° F. (2.6° C.) and 5.8° F. (3.2° C.) in 2 cases. In 2 control birds, where the air-sacs were left intact but the operation details were similar, when the flight muscles were tetanized, a rise in body temperature of only 1.3° F. (0.7° C.) and 1.6° F. (0.9° C.) occurred. This would indicate that excess heat is eliminated through this air-sac system.

A little evidence was presented in a former paper (Kendeigh and Baldwin, 1928) from the development of temperature control in young birds, which would indicate that in the eastern house wren the air-sacs begin to function at about the time that the bird acquires a temperature control—that is, between the fourth and ninth days after hatching. In chickens, the air-sacs are fully developed soon after hatching, and temperature control is established at the same time.

As a further study of the development of air-sacs in birds, a preliminary attempt was made to determine the progressive decrease in specific gravity of young house wrens during the first 12 days after hatching. By a simple device involving the

displacement of water in a small calibrated tube, it was possible to determine the volume of the birds in cubic millimeters. Since a cubic millimeter of water weighs approximately 1 milligram, the specific gravity of the bird could be determined by dividing the volume of the bird in millimeters by the weight of the bird in milligrams. What few data were obtained indicate a high specific gravity of the birds at hatching but a considerable decrease during the period in the nest. This might be taken as an argument that the air-sacs are forming and penetrating into the body and bones of the bird at the same time that the temperature regulation is becoming established, and that the development of the two may be interrelated.

Thus it would seem that the temperature control mechanism in birds is a complex apparatus. It is difficult to evaluate the importance of each of the different factors involved. Undoubtedly, the body temperature of the bird is dependent upon a proper balance between all the factors.

BODY TEMPERATURE OF NESTLING BIRDS

POIKILOTHERMIC (COLD-BLOODED) STAGE IN DEVELOPMENT OF WARM-BLOODED ANIMALS

In the case of the human species, newly-born babies do not have body temperatures as high as adults nor is their temperature control as well perfected (Raudnitz, 1888; Babák, 1902; Benedict and Talbot, 1915). Both their body metabolism and temperature are variable and subject to differences in environmental temperature. This fact is well known to physicians and nurses, and care is always taken to keep the baby warm by artificial means. According to Kimber and Gray (1923), "the human fetus is cold-blooded," and the heat regulating mechanism is not "in working order" during the first few weeks after birth.

In certain other species of mammals, a similar lack of temperature control has been shown to be true (Sumner, 1913). In mice, the power of heat regulation for moderate air temperatures (68°–77° F. [20.0°–25.0° C.]), is pretty well established at about the age of 10 days. For lower temperatures, however, the power of regulation is not developed until much later, apparently not until the age of 20 days. In a more recent work (Stier and Pincus, 1928), it was shown that when 2-day old mice were exposed to a temperature of 61° F. (16.1° C.) they assumed a body temperature only about 0.2° F. (0.1° C.) higher; although when the air temperature was 93° F. (33.9° C.) their body temperatures were 3°–5° F. (1.7°–2.8° C.) higher. In his classic review of 1839, Edwards tells that when young puppies were exposed to low temperatures their body temperature dropped to within 1.0° F. (0.6° C.) of the environment. He further states, "They may be said to be, to all intents and purposes, cold-blooded animals, with reference to temperature, during the earliest period of life; they are only truly warm-blooded animals in a later stage of their existence."

Other young animals, however, as illustrated by the guinea-pig and goat, have, apparently, a fairly well developed regulating mechanism at birth. This may be correlated with the better development of also the nervous and circulatory systems at birth.

With regard to the production of heat, Edwards divides the young of birds into two groups. "The one comprises those that are hatched with the skin naked, and which cool in a temperate air in the same manner as cold-blooded animals; the other embraces those that are produced with a downy covering, and maintain their temperature at a considerable elevation in the ordinary heat of spring and summer." He tells of a young sparrow's losing 22° F. (12.2° C.) of its body temperature in 1 hour and 7 minutes when subjected to an air temperature of 72° F. (22.2° C.). Pembrey, Gordon, and Warren (1894), working on the respiration of the domestic fowl, found that "the developing chick during the greater part of the period of incubation responds to changes of external temperature in a similar manner to that of a cold-blooded animal; that towards the end of incubation, about the 20th and 21st day, there is an intermediate stage in which no marked response is observed, and this apparently neutral condition is succeeded, when the chick is hatched, by a stage in which the chick reacts as a warm-blooded animal." From some preliminary work of our own on the temperature of chicks soon after hatching, a comparatively stabilized control of body temperature was demonstrated, although this control was less perfect than in other chicks 3 days old. The domestic fowl would fall into Edwards's second group.

Leichtentritt (1919) subjected newly hatched chickens, sparrows, and blackbirds to low and high air temperatures, and found that they had an undeveloped temperature control. Wetmore (1921) gives a few data indicative that young birds have lower and more variable temperatures than adults. The most extensive discussion of the development of temperature control in an altricial species is one by the authors (Kendeigh and Baldwin, 1928). Here it was shown that the ability for maintaining a fairly constant temperature was not attained in the eastern house wren until the ninth day after hatching. Before the ninth day the birds are essentially cold-blooded.

Recently, Gardner (1930) has reported an interesting study on the temperature of nestling birds of 24 species, using mercury

thermometers, and he finds their temperatures to be variable. The effect of various factors on body temperature was ascertained. Age in these birds was important, since their temperature rose gradually as the time after hatching lengthened. He states that the temperature of the nestlings, at the time of leaving the nest, is, in most cases, considerably below the average temperature normal to the species. This statement is doubtful, because his information as to the "mean temperature normal to the species" is uncertain. He is right, however, in considering air temperature important in its relation to nestling bird temperatures. Exertion or muscular activity, he finds, raises the temperature of nestling birds. This is certainly the case with adult birds; but we have found, in the case of nestling house wrens, that before they have fully developed a temperature control, exertion or struggling frequently lowers the body temperature, due to the cooling effect of increased respiration that takes place at the same time and which sometimes is more than enough to compensate for the increased heat produced by the activity (Kendeigh and Baldwin, 1928). Gardner was working with larger birds in this connection, i.e., turkey vulture, red-tailed hawk, and great horned owl, and it is quite possible that they behave differently. He is quite right in saying that handling of birds may cause a drop in body temperature, and that fatigue, hunger, illness, and absence of the incubating parents have the same effect. His evidence regarding the effect of ingesting cold masses of food on body temperature is not altogether convincing, although his conclusion that a transitory lowering of temperature is produced is not illogical.

The evidence presented in the preceding paragraphs indicates that, so far as temperature reactions are concerned, all warm-blooded animals—birds and mammals, including man—pass through a poikilothermal or cold-blooded state in the course of their development. In some of these animals, such as the chicken, guinea-pig, and man, this stage is, for the most part, passed through before birth, but in other species this does not occur till several days afterwards. That this is of interest from the phylogenetic standpoint is at once apparent, and constitutes another link in the evidence that mammals and birds arose in times past from cold-blooded ancestors, and that in the course of their ontogenetic development this phylogenetic stage is still represented.

DEVELOPMENT OF TEMPERATURE CONTROL IN YOUNG BIRDS

In our former paper (Kendeigh and Baldwin, 1928), the development of temperature control in nestling house wrens was traced in some detail. More work has been done on the subject since that paper was published so that a new curve of development (Figure 28) has been made. This is in general very similar to the one first published but it is altered somewhat for the last few days.

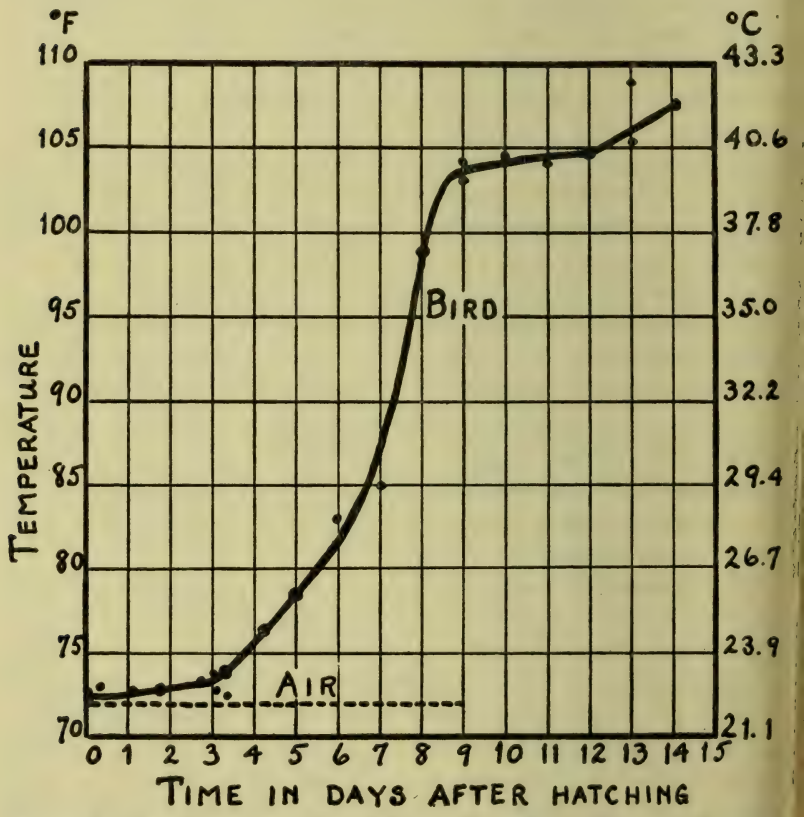


FIGURE 28.—DEVELOPMENT OF TEMPERATURE CONTROL IN NESTLING EASTERN HOUSE WRENS. Note the rapid and progressive gain from the fourth to the ninth day. The temperature control mechanism is established after the ninth day. Before that time, the bird's temperature varies more or less with that of the air. The number of degrees that the body temperature can attain above the air on the bird's own resources is shown for the first nine days above a uniform air temperature of 72°F. (22.2°C.).

The points on this curve represent the highest body temperature that the young birds could attain when removed from the nest and placed alone in semi-darkness at a room temperature of approximately 72.0° F. (22.2° C.).

The sigmoid (S-shaped) nature of the curve is evident up to 12 days. The factors involved in the development of temperature control, are, as given in our earlier paper, first, that the mass or size of the body increases proportionally faster than the surface. This would cause an increase in the amount of heat production with more protoplasmic material involved, yet the surface

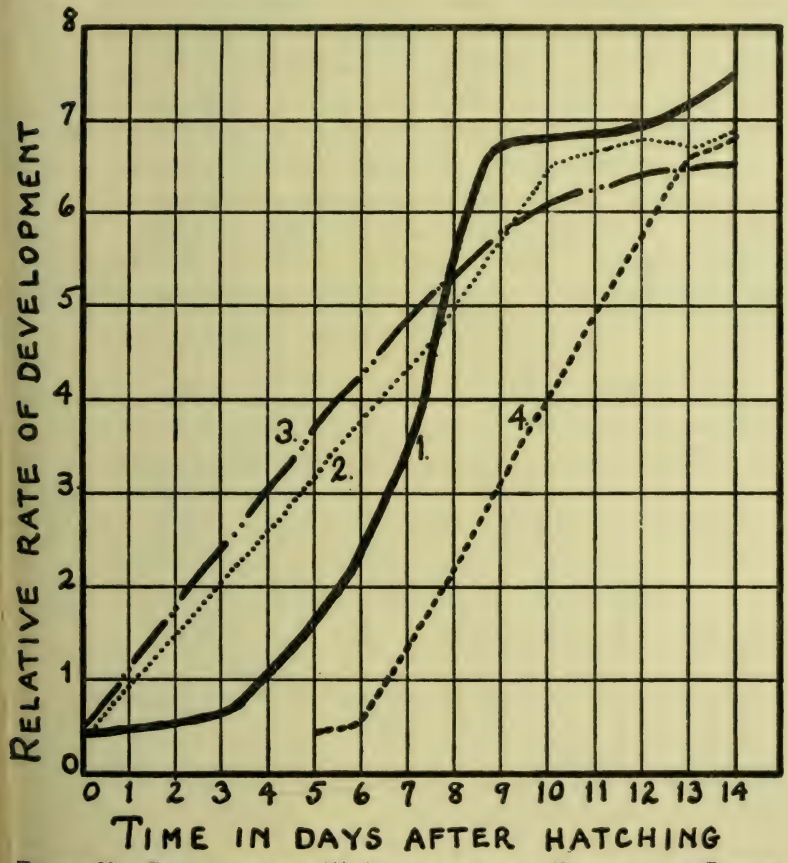


FIGURE 29.—CORRELATION OF (1) DEVELOPMENT OF TEMPERATURE CONTROL IN THE EASTERN HOUSE WREN WITH (2) DEVELOPMENT OF BODY WEIGHT, (3) BODY SIZE, AND (4) FEATHERS.

for heat dissipation would not increase sufficiently to keep up with the heat produced, so that the body temperature would be raised. This effect continues for about 10 days, after which the body does not increase much in weight or size (Figure 29). However, the influence of this factor is most apparent during the first 3 or 4 days, because its proportionate influence then is greater and other factors do not obscure it so much. In our investigations, size was measured by the length from the anterior end of the sternum to the anus.

Another factor involved in the development of temperature control is the growth of feathers. The curve showing feather growth (Figure 29) is an average for feathers on all feather tracts of the body, and is taken from data obtained by Boulton (1926) at this laboratory. External feather development begins soon after the first rapid ascent in the general curve of temperature control, and rapid feather development occurs throughout the period of most rapid temperature development. After 9 days the curve for temperature control flattens out, while that of feather development continues at nearly the same rate as before. This would indicate either that the development of feathers is not the only factor or the most important factor involved, or that the elongation of feathers beyond a certain point is not important.

A factor that we believe of considerable importance in the temperature regulation mechanism is the development of air-sacs and the use of respiration for the proper interchange of heated and cooled air in the body. There is some evidence to indicate that the development of these is sufficient between the fourth and ninth days definitely to establish a temperature control at the end of this time (Kendeigh and Baldwin, 1928). Gross anatomical examination of newly hatched nestling wrens does not reveal the presence of air-sacs, although late in the nestling period they occur. Two diseased birds respectively 9 and 10 days old possessed bloated abdominal air-sacs as though the normal mechanism were not functioning properly at this time. Further evidence in this connection is presented in the section dealing with the rate of respiratory movements in young birds. Coupled with the functioning of these organs and other factors involved is, of course, the development of a nervous system sufficient to control their activities.

The closing of the fenestra in the interauricular septum of the heart and the atrophy of the ductus Botalli with the development of a complete double circulation of blood are probably also involved (Locy and Larsell, 1916), and may account, in part, for the gradual increase in body temperature during the developmental period.

The metabolism of the body tissues in the production of heat is, of course, a factor of prime importance. Air-sacs and respiration could not alone give a control of body temperature, since they are involved only in regulating the loss of heat, not in its production. There is undoubtedly an increase in total heat production in the young bird as it becomes older, but this has not yet been measured. The amount of heat production is probably tied up with also the development of nervous and endocrine regulation, so that the whole development is very complex.

The most rapid development of temperature control (Figure 28), begins when the nestling is 4 days old and continues until it is 9 days old. After that the curve flattens out for 3 days, but from 12 to 14 days it rises again. Possibly this latter increase in temperature is due to some effect of the control mechanism, but it may be due to an actual increase in heat production by the young birds.

Some direct studies of standard metabolism of young domestic chickens at various ages have been made for comparison with the adults. Mitchell, Card, and Haines (1927) found that "the metabolism per unit of surface is distinctly below the adult level at hatching, rises rapidly to a maximum, and then decreases again to the adult level that is maintained for a considerable fraction of the life span. For the chicken, the peak in the curve appears to be reached at 30 to 40 days of age, and the adult level at about 70 to 80 days." For altricial species, these time intervals would be different, coming probably earlier. Groebbels (1928–a) states and gives evidence that the oxygen intake of altricial nestlings is higher than that of adults. In a recent study of metabolism during growth in the common pigeon, Riddle, Nussmann, and Benedict (1932) found that 3 days after hatching the metabolism of the bird was 20% higher than the standard metabolism of the young adult; at 11 days after hatching, it was about 100% higher; while

at 23 and 25 days after hatching, the rate of metabolism was in rapid decline that continued until the adult level was reached.

In order to obtain some data for comparison between adult and young house wrens with regard to their basic temperature regulation, standard temperatures (page 22) of nestling birds from the age of 11 to 36 days were obtained in the same way as for adults; i.e., after the birds remained 2 hours without food and were at as near complete rest as was possible to attain. The air temperature averaged 74.1° F. (23.4° C.).

TABLE XVII.—*Standard Temperature of Immature Eastern House Wrens after Establishment of Temperature Control*

Age	Date	Standard Temperature
11 days	July 25, 1928	104.0° F. (40.0° C.)
12 "	July 26, 1928	104.0° F. (40.0° C.)
13 "	August 10, 1927	104.5° F. (40.3° C.)
14 "	August 7, 1928	104.5° F. (40.3° C.)
14 "	August 14, 1928	104.9° F. (40.5° C.)
14 "	August 7, 1927	105.1° F. (40.6° C.)
14 "	August 9, 1928	105.4° F. (40.8° C.)
15 "	August 10, 1928	105.5° F. (40.8° C.)
36 "	August 20, 1928	104.2° F. (40.1° C.)
Average (9 records)		104.7° F. (40.4° C.)

In these records no distinction was made between sexes (Table XVII). The average result of 104.7° F. (40.4° C.) is of interest, since it is exactly half way between the values obtained for the standard temperatures of the two sexes of adult birds, which was 104.4° F. (40.2° C.) for the male and 105.0° F. (40.6° C.) for the female. There is evident a gradual rise in the standard temperature of these young birds from 11 days to 15 days of age. This may be directly correlated with the rise also in the curve for temperature control, particularly during the last 2 days. The temperature record for the 36-day-old bird is again low, simulating the standard temperature found in adult males. If the standard temperature is any measure at all of standard metabolism, then the statement made by Mitchell, Card, and Haines quoted above would hold for the house wren also, although

the point of maximum metabolism would be attained at an earlier age.

The temperature control mechanism is more or less functional when the bird becomes 9 days old. The bird is then able to withstand moderate air temperatures on its own resources. A perfect control against low air temperature is not, however, developed for some time after leaving the nest. During damp, cold weather the young birds are likely to suffer greatly. Rainy days in particular are likely to be hard on young birds, as illustrated by 2 cases which have come to our attention; one was a bird 15 days out of the nest which had a gullet temperature of only 102.6° F. (39.2° C.); another 21 days out, had a temperature of 100.7° F. (38.2° C.). Many birds, in this juvenal period, undoubtedly perish each year during unfavorable weather conditions.

Although there is thus developed a complex control mechanism in young birds for resistance to low air temperatures, practically no resistance to high temperatures is developed. In fact, young birds before developing feathers are able to withstand high air temperatures better than adults, when placed under similar conditions in the laboratory. Referring again to our former paper (Kendeigh and Baldwin, 1928), we presented data showing that, when young birds of different ages were placed at an air temperature of 102° F. (38.9° C.) the body temperature of the older birds with feathers rose several degrees higher than did that of the young birds. This rise in temperature is probably due to the inability of the older birds to dissipate excess heat fast enough. The feathers then become a liability, since they prevent radiation from the general surface of the body. Practically the only ready means of losing heat is respiration; and the bird, therefore, responds by accelerating its rate of breathing, sometimes more than 300 per cent, so that doubtless there is a considerably increased circulation of air through the air-sacs and lungs. The efficiency of this control is, however, very limited, and within a short time, if the high air temperature persists, the bird dies of hyperpyrexia. Feathers, however, serve as an important protection of birds against sun temperatures, as will be discussed later (page 121).

RATE OF RESPIRATORY MOVEMENTS IN YOUNG BIRDS

Many determinations of the rate of respiratory movements at different body temperatures in young house wrens of different ages were made, and these produced some interesting results. The breathing rate of nestling house wrens recently hatched is comparable to that in young mice before they also have attained an adequate temperature control (Pincus, 1931). In the eastern house wren the number of respirations per minute was measured by actual count with watch in hand. The rate varies directly with body temperature in the younger birds but becomes modified at certain temperatures in older individuals. For instance, in birds only recently hatched, respiration was 24 times a minute when the body temperature was 83° F. (28.3° C.); 10 times at 78° F. (25.6° C.); 6 times at 72° F. (22.2° C.); 2 times at 62° F. (16.7° C.); 1 per minute between 59° F. (15.0° C.) and 57° F. (13.9° C.); about 2 in 3 minutes from 57° F. (13.9° C.) down; while at 49° F. (9.4° C.) the bird ceased breathing altogether. Several times with birds only a few hours old, all visible breathing movements of the body had ceased, and the birds, believed dead, were removed from the apparatus; but to determine certainly whether or not they really had succumbed, they were placed in an incubator and found after a few minutes to be as much alive and active as ever. Visible breathing movements cease, therefore, particularly in very young birds, at a temperature still too high actually to produce the death of the organism. In this state, the bird is comparable to a hibernating mammal or a dormant poikilotherm, although the bird cannot exist as long. In one instance, in a bird 5 days old a peculiar type of respiration was observed when the body temperature had dropped to 54° F. (12.2° C.); that is, the bird breathed 3 times close together, then waited a while and again breathed 3 times together. In other individual birds, when the actual body movements involved in normal respiration had ceased, there were discernible on closer examination slight movements of the mandibles, indicating that there may still have been some slight movement of air in and out of the body. This general behavior of the respiratory system in respect to temperature is another proof of the poikilothermic nature of the young house wren.

As the young bird becomes older it breathes more and more rapidly when compared at normal body temperatures. The highest rate that we have observed in young birds is 380 times per minute in a bird 10 days old at a body temperature of 114° F. (45.6° C.). At a body temperature of 104° F. (40.0° C.), the rate is 102-106 times a minute for birds of an age of 5 days or more. This is slightly higher than the rate of adults at the same body temperature.

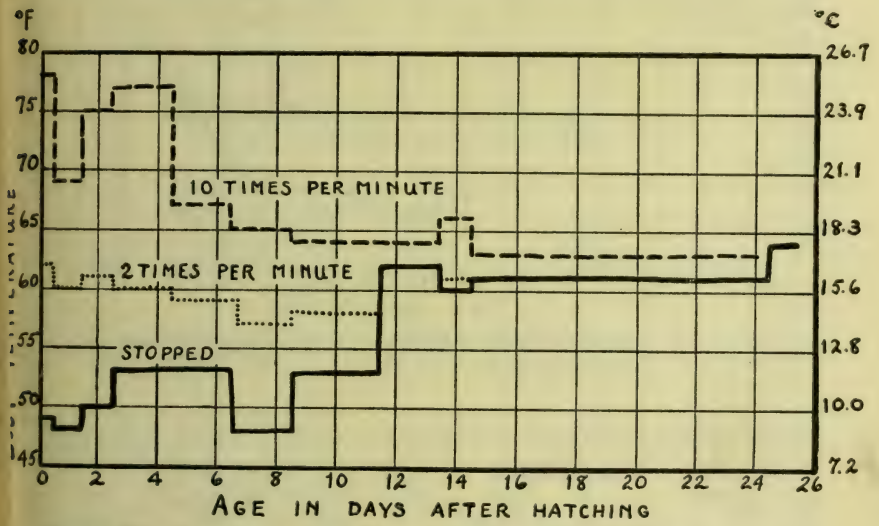


FIGURE 30.—VARIATION IN THE EXTENT TO WHICH THE BODY TEMPERATURE OF IMMATURE EASTERN HOUSE WRENS OF DIFFERENT AGES MUST BE LOWERED TO REDUCE THE RATE OF BREATHING TO TEN TIMES PER MINUTE, TO TWO TIMES PER MINUTE, AND TO STOP IT ALTOGETHER.

The body temperature at which young birds cease breathing is higher as they become older (Figure 30). This is probably due to the fact that the respiratory mechanism is becoming more and more attuned to functioning in a homoiothermic condition. The body temperature at which breathing becomes reduced to 2 times per minute runs about the same throughout the first 25 days. However, the body temperature required to reduce the number of respirations to 10 per minute is lower, the older the bird. This indicates again that the younger birds are less able than the older ones to maintain a constant and high rate of breath-

ing, and are more subject to the temperature influence of the environment.

In the curve of respiration for the adult bird presented above (Figure 10), the breathing is less at a body temperature of 104°–105° F. (40.0°–40.6° C.) than either immediately above or below. When is this sort of a curve first found in young birds?

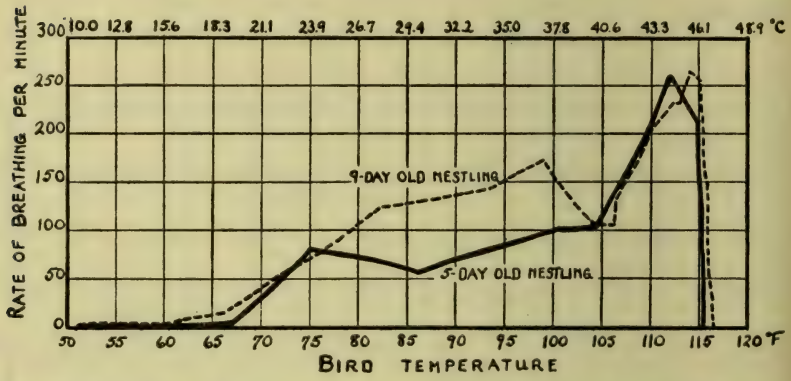


FIGURE 31.—RATE OF BREATHING MOVEMENTS IN NESTLING EASTERN HOUSE WRENS OF TWO DIFFERENT AGES AT DIFFERENT BODY TEMPERATURES.

In Figure 31, similar curves are plotted for the rate of respiration at different body temperatures of house wrens respectively 5 days and 9 days old. No curve is given for birds younger than 5 days, but all the evidence indicates that the rate of the respiratory movements varies more or less directly with body temperature. With the bird 5 days old this is nearly true, but there is a flattening of the curve between 75° F. (23.9° C.) and 104° F. (40.0° C.). Two individuals are made use of here to complete the entire range of temperatures. With the birds 9 days old, 2 individuals are again made use of in order to have the entire scale of temperatures represented. The composite curve for the bird 9 days old is very similar in many respects to that of the adult birds. There is a minimum rate at 104°–106° F. (40.0°–41.1° C.), an increase as the body temperature both rises and falls, and then as the temperature control is broken by a drop in temperature, a direct variation with temperature. The attaining of this curve at this age seems to us to be of considerable signi-

ficance, because it is between the fourth and ninth days that temperature control is obtained, and it is supposedly during this time that the air-sacs begin to function in respiration. This, then, would be another argument in favor of the air-sacs and respiration as a vital factor in the temperature regulating mechanism.

As the body temperature rises, the rate of respiration increases to a maximum and then rapidly decreases in birds of both 5 and 9 days of age. This is the same thing that occurs in adult birds, although in young birds the fall in rate of respiration, after the maximum is reached, occurs before the body temperature has attained its maximum.

RESISTANCE OF YOUNG BIRDS TO HIGH TEMPERATURE

The temperature responses of young house wrens to high and low air temperatures were determined in a similar manner as were those of the adults (pages 42–50). Use was made of the air chamber in which the bird was placed, and the temperature was varied by means of a water bath running around this (Plate III). The humidity approximated that of normal air temperature outside and was the same as in the experiments with adult birds. The rate of ventilation averaged about 60 cubic centimeters per minute, and this was amply sufficient, as was shown by the behavior of the controls run before the experiments were started.

A few figures (Figures 32-34) are here given to show the manner in which a young bird's temperature increases as the air temperature is raised. In Table XVIII, the lethal points in both

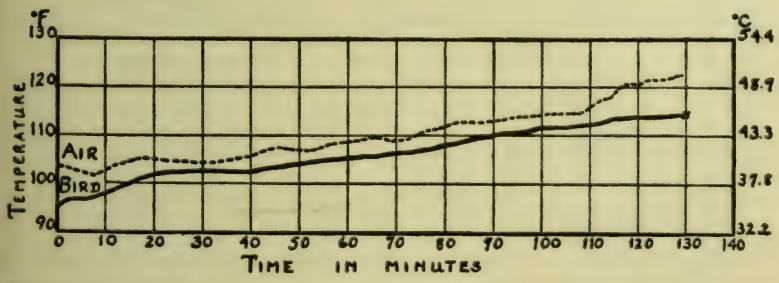


FIGURE 32.—EFFECT OF A HIGH AND RISING AIR TEMPERATURE ON THE BODY TEMPERATURE OF A NESTLING EASTERN HOUSE WREN ONE HOUR OLD. The cross marks point of the bird's death.

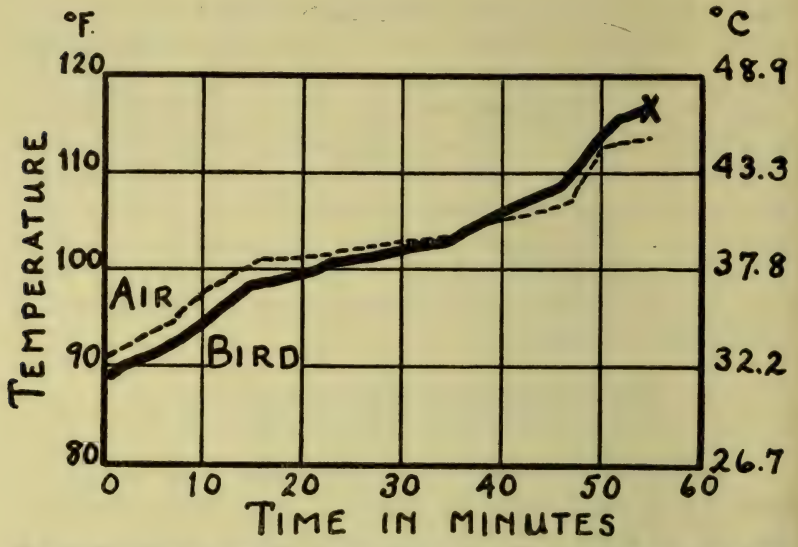


FIGURE 33.—EFFECT OF A HIGH AND RISING AIR TEMPERATURE ON THE BODY TEMPERATURE OF A NESTLING EASTERN HOUSE WREN THREE DAYS OLD. The cross marks point of bird's death.

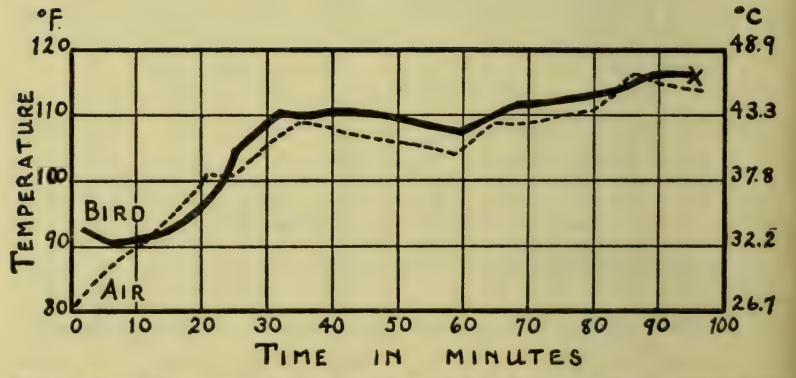


FIGURE 34.—EFFECT OF A HIGH AND RISING AIR TEMPERATURE ON THE BODY TEMPERATURE OF A NESTLING EASTERN HOUSE WREN SEVEN DAYS OLD. The cross marks point of bird's death.

bird and air temperatures are shown. When these danger points were reached in less than an hour or in an hour and a half, the rate of temperature change is indicated in that table respectively as (46.6° C.). The rate at which the air and bird temperatures are raised or lowered more slowly, the rate of change is designated "moderate."

The upper lethal body temperature, in the 10 instances determined for various ages of immature birds, averages 115.9° F. (46.6° C.). The rate at which the air and bird temperatures are raised, is, however, important. In the 6 cases, where this was

TABLE XVIII.—*Effect of High and Low Air Temperatures on the Body Temperature of the Immature Eastern House Wren*

Air Temperature Raised				
Age of Bird	Highest Body Temperature Attained	Air Temperature at Same Time	Rapidity of Temperature Change in Air and Bird	Survival of Bird
1 hour	114.1° F. (45.6° C.)	116.1°–117.7° F. (46.7°–47.6° C.)	Moderate	No
1.5–2 days	116.1° F. (46.7° C.)	107.2°–119.2° F. (41.8°–48.4° C.)	Very fast	No
2.5–3 "	117.0° F. (47.2° C.)	113.0° F. (45.0° C.)	Fast	No
3 "	113.5° F. (45.3° C.)	105.5°–119.5° F. (40.8°–48.6° C.)	Fluctuating	Yes
5 "	115.5° F. (46.4° C.)	117.0° F. (47.2° C.)	Moderate	No
7 "	116.0° F. (46.7° C.)	114.9° F. (46.1° C.)	Moderate	No
9 "	116.6° F. (47.0° C.)	115.0° F. (46.1° C.)	Moderate	No
10 "	117.1° F. (47.3° C.)	107.8° F. (42.1° C.)	Fast	No
10 "	116.9° F. (47.2° C.)	111.4° F. (44.1° C.)	Fast	Yes
11 "	118.5° F. (48.1° C.)	120.0° F. (48.9° C.)	Very fast	No
13 "	116.1° F. (46.7° C.)	107.4°–111.0° F. (41.9°–43.9° C.)	Moderate	No
16 "	111.6° F. (44.2° C.)	107.1°–105.2° F. (41.7°–40.7° C.)	Moderate	No

Air Temperature Lowered				
Age of Bird	Lowest Body Temperature	Air Temperature at Same Time	Rapidity of Temperature Change in Air and Bird	Survival of Bird
Just hatched	49.0° F. (9.4° C.)	45.3° F. (7.4° C.)	Moderate	Yes
6 hours	52.4° F. (11.3° C.)	50.0° F. (10.0° C.)	Fast	Yes
1 day	47.4° F. (8.6° C.)	47.0° F. (8.3° C.)	Moderate	No
2 days	49.4° F. (9.7° C.)	47.4° F. (8.6° C.)	Moderate	Yes
3 "	50.7° F. (10.4° C.)	47.2°–50.1° F. (8.4°–10.1° C.)	Fast	Yes
5 "	56.0°–47.0° F. (13.3°–8.3° C.)	50.0°–46.0° F. (10.0°–7.8° C.)	Moderate	No
5 "	44.2° F. (6.8° C.)	43.5° F. (6.4° C.)	Fast	No
7 "	46.5° F. (8.1° C.)	44.5° F. (7.0° C.)	Moderate	No
9 "	47.6° F. (8.7° C.)	47.0° F. (8.3° C.)	Moderate	Yes
12 "	50.5° F. (10.3° C.)	48.5° F. (9.2° C.)	Moderate	No
14 "	60.0° F. (15.6° C.)	53.8° F. (12.1° C.)	Fast	No
15 "	61.5° F. (16.4° C.)	50.9° F. (10.5° C.)	Moderate	Yes
25 "	63.2° F. (17.3° C.)	59.0° F. (15.0° C.)	Moderate	No
5 weeks	72.6° F. (22.6° C.)	62.6° F. (17.0° C.)	Fast	Yes

moderate, the average is 115.0° F. (46.1° C.); and in the 4 cases where it was rapid, it is 117.2° F. (47.3° C.), a difference of 2.2° F. (1.2° C.). The age of the young birds has apparently no effect upon the point at which the lethal body temperature is reached. In fact, except for the rate at which the temperature was reached, the amount of variation is very small, and the lethal body temperature is nearly the same as that determined for the adult birds, which is 116.3° F. (46.8° C.). Apparently after the temperature control is broken, the body tissue reacts similarly regardless of age. The dying of the 16-day-old bird when its body temperature rose only to 111.6 F. (44.2° C.) is exceptional.

The exact temperature of the air that is effective in producing death is difficult to determine with entire satisfaction in every case. The bird reacts positively to all variations in the air temperature, either up or down, provided, of course, that these are of sufficient degree. The attempt was made, however, to ascertain the lowest point at which a high temperature would cause the bird's death, and this was more or less successfully done. The average air temperature for all 11 birds when death occurred was 113.3° F. (45.2° C.). Age is an important factor here. If we average together the air temperatures causing the death of birds that have just hatched to those 3 days of age inclusive, we get 113.9° F. (45.5° C.). A similar average for birds from the ages of 5 to 10 days is 113.2° F. (45.1° C.), and from 11 to 16 days 107.7° F. (42.1° C.). The record of 120° F. (48.9° C.) in air temperature for an 11-day-old bird is not included in this average, since the temperature was increased so very fast in that experiment that the results are not typical. However, even if included, the average for the older birds would be nearly a degree and a half less than that of the second group. For adult birds, a similar average would be approximately 100° F. (37.8° C.) air temperature. There is thus, with increasing age, a progressive decrease in tolerance to the high air temperature that birds can resist. This is probably due to the greater difficulty that the birds have of dissipating excess heat when they become larger and covered with feathers. Here again, the warning is given that these critical air temperatures were obtained with birds in confinement and are probably not applicable in all detail for birds under natural conditions.

In order to see how long young house wrens would survive the full effect of the heat of the sun, 3 birds were placed in open boxes exposed directly to the sun at 2:02 P. M. on one bright, clear day. One of the birds had hatched on that morning, another was 4 days old, while the third was 14 days old. At 2:11 o'clock, all birds were alive, but breathing rapidly and panting. At 2:17, the 2 younger birds were dead. The oldest bird lived throughout the experiment, which was continued until 3:30 P. M. The general air temperature in the shade at 2:30 P. M., taken at our regular weather station, was 85.5° F. (29.7° C.). However, a thermometer, the bulb of which was wrapped several times around with black mosquito netting and placed exposed to the sun near the birds, gave a reading of 109°–110° F. (42.8°–43.3° C.). The 2 naked younger birds did not live 15 minutes, the older feathered one was not killed. This appears at first contradictory to our experimental results. Further analysis, however, suggests that the feathers of the oldest bird, the only one to survive, served a very useful function of protecting the bird from the direct insolation of the sun, so that the body of the bird was actually subjected to a much lower air temperature than were the 2 naked young. Feathers may furnish birds as much protection in the summer by shielding them from direct solar radiation as they do in the winter by insulating them against intense cold.

The fatal effect of high body temperatures is almost instantaneous. Sometimes only a few seconds or at most only a very few minutes are all that are required. However, by lowering the body temperature after the upper lethal temperature is reached, this short period before death may be prolonged for a few minutes.

RESISTANCE OF YOUNG BIRDS TO LOW TEMPERATURE

That the body temperature of young birds is very responsive to low air temperature when they are exposed directly to it was shown in some detail in our former paper (Kendeigh and Baldwin, 1928). They are dependent on outside sources of heat for the maintaining of their own temperature, and if this fails them their body temperature drops at once. In Figure 35, which is illustrative of many others that might be given, the correspondence in the

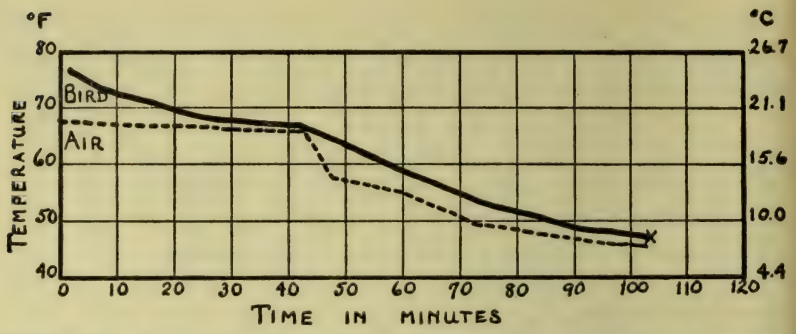


FIGURE 35.—EFFECT OF A FALL IN AIR TEMPERATURE ON THE BODY TEMPERATURE OF A NESTLING EASTERN HOUSE WREN FIVE DAYS OLD. The cross marks the point of bird's death.

curves for the body and air temperatures is well marked. In young house wrens just hatched, the evaporation of water from the skin sometimes lowers the body temperature to or below the air temperature. The temperature of the living bird does not ordinarily decrease quite to air temperature, however. Ordinarily the normal metabolism or heat production of the bird is sufficient to keep the body temperature above that of the air, even with birds less than a day old, and this difference may persist for several hours. In the case of 1 young bird, 3 days old, an average of 1.5° F. (0.8° C.) above that of the air, which was 65°–66° F. (18.3°–18.9° C.), was maintained with very little fluctuation for nearly 14 hours. When the air temperature is fluctuating or rising too rapidly, the bird's temperature may then drop below that of the air, due to a lag in the warming up of the bird, but this would naturally be expected.

After realizing that the body temperature of young birds is dependent on that of the environment, and that a drop in the environmental temperature causes a rapid and corresponding drop in the temperature of the bird, the question arises as to how low the temperature of the young bird can be caused to drop before death ensues, and what temperature of the air is required to do this. To determine this, use was made of the temperature bath as above described (Plate III), but with ice water instead of water which had been heated. Air temperatures down to 44° F. (6.7° C.) could be obtained in this way, which was sufficiently low for most of the experimentation.

It is more difficult to kill a bird by low temperature than by high. This is because heat is a more potent destructive agent to protoplasm than is chill, and because the normal body temperature maintained by birds is nearer the upper lethal limit than the lower. Adult house wrens do not survive a lowering of their body temperature to 71.0° F. (21.7° C.). The temperature of young birds may drop much below this without death's resulting. Age is, in this connection, a very important factor (Table XVIII), so the data on young birds are here presented in the reverse order of the age of the birds.

A juvenal house wren, 5 weeks old, survived a lowering of its body temperature to 72.6° F. (22.6° C.). Another, 25 days old, was killed when its body temperature dropped to 63.2° F. (17.3° C.). A house wren 15 days old survived a body temperature of 61.5° F. (16.4° C.); but a bird 14 days old was killed at 60.0° F. (15.6° C.), and a 12-day bird died at about 50.5° F. (10.3° C.). The effect of these low body temperatures seems to be an absolute one, i.e., the effect is immediate if it is to occur at all. The length of exposure was not here an important factor, since the bird's temperature dropped continuously until it reached a certain degree that proved fatal. The case of the bird 3 days old, above mentioned, shows that low temperatures which are not fatal can be endured for several hours. Death results in such cases only when starvation has greatly weakened the bird's resistance. This will be considered in more detail later. In the last 3 cases above, the air temperature ranged from about 48.5°–53.8° F. (9.3°–12.1° C.).

In a previous section (pages 108–113), we showed that nestling house wrens develop a temperature control mechanism which enables them after an age of 9 days to maintain their body temperature constant at a moderate air temperature (72° F. [22.2° C.]). This does not permit them to withstand the unusually low air temperatures produced in this series of experiments, particularly when the air temperatures are purposely lowered at a very rapid rate.

Of house wrens from 5 to 9 days old, 1 bird, 9 days old, survived a body temperature of 47.6° F. (8.7° C.). A house wren, 7 days old, was killed at 46.5° F. (8.1° C.), and one 5 days old at 44.2° F. (6.8° C.). Another bird, 5 days old, died somewhere between 56° F. (13.3° C.) and 47° F. (8.3° C). The range in

air temperature was from 43.5° F. (6.4° C.) to about 48.0° F. (8.9° C.). These figures must be considered as only approximate, for it is not always easy to determine the exact moment when death occurs, since in very young birds life may linger on for some time even after visible breathing has ceased. The stopping of the respiratory movements is a danger signal, however, and one that could be ascertained rather readily in these experiments. In any case of doubt as to whether the bird had actually died or not, the bird was removed and placed in an incubator for several minutes at a temperature of approximately 100° F. (37.8° C.).

For house wrens less than 5 days old there are 5 records. Four of these survived body temperatures from 49.0° F. to 52.4° F. (9.4° C. to 11.3° C.) and air temperatures from 45.3° to 50.0° F. (7.4° to 10.0° C.). One bird about 1 day old died at a body temperature of 47.4° F. (8.6° C.) with the air temperature at 47.0° F. (8.3° C.).

From the data given above it would seem, therefore, that 47.0° F. (8.3° C.) is approximately the low lethal body temperature for those young birds that have not yet developed a temperature control; and that this corresponds to an effective air temperature from a few tenths of a degree to 2° or 3° F. (1.1° or 1.7° C.) below this, depending on the age and size of the birds. Reduction of body temperature to any degree above this limit is not fatal. The young birds may be again warmed, returned to the nest, and develop normally. Gross (1930) states that young prairie chickens when cooled to a nearly lifeless condition will also recover rapidly when again brooded.

SURVIVAL TIME OF YOUNG BIRDS AT HIGH AND LOW TEMPERATURES

Our next series of experiments was for the purpose of determining the survival time of young birds without food at normal temperatures of the nest, and also when exposed to low air temperatures. Young birds of different ages were taken from the nest, brought to the laboratory, and placed either in a well-ventilated incubator at 99° F. (37.2° C.) or in open boxes at a room temperature of 66° F. (18.9° C.). The humidity at the higher temperature averaged about 65%, while that at the lower was at least 82%. Of course, the food factor is an important one in such a

case, as the birds were not fed at any time during the experiment —this would have been useless, as any food forcibly ingested would not have been digested by young birds at greatly reduced temperatures. The problem really amounts, then, to the determination of how long young birds can live without food at one temperature as compared with another.

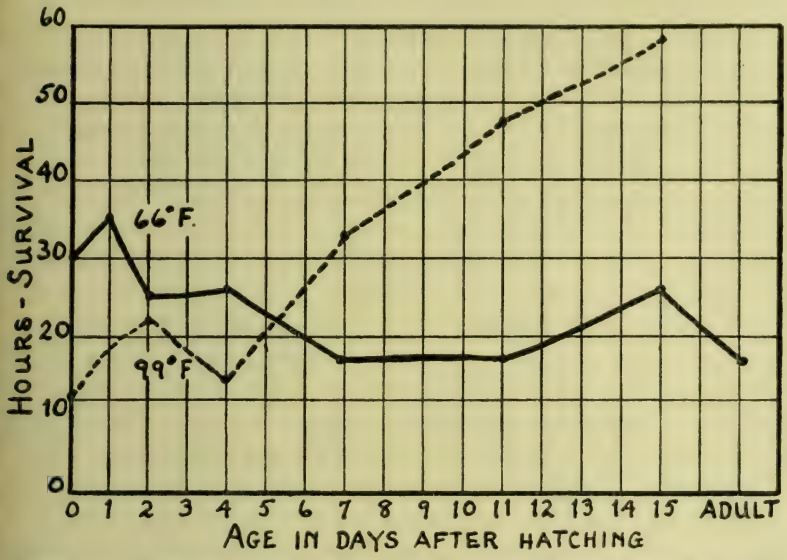


FIGURE 36.—SURVIVAL TIME OF NESTLING EASTERN HOUSE WRENS OF DIFFERENT AGES AT DIFFERENT AIR TEMPERATURES AND WITHOUT FOOD. The air temperatures used were 66°F. (18.9°C.) and 99°F. (37.2°C.).

The results are shown in Figure 36. The survival time is plotted in hours against the age of the birds in days. The accuracy of the survival time as determined is about 2 hours, plus or minus. The figure shows that young birds less than 5 days old live longer at the lower temperature than at the higher, while above the age of 6 days the reverse is true. This is interesting when we remember that it is between the fourth and ninth days that the birds develop a temperature regulation, and that previously to this they react as cold-blooded animals.

That cold-blooded animals would live longer at low temperatures than at high is natural and a fact well known. Some physiological processes have been found to obey van't Hoff's law for chemical

reactions. This law states that for every rise of 18° F. (10.0° C.) there is a twofold or threefold increase in the rate of reaction. Metabolism of these young birds would be kept normal and high at the incubator temperature, but greatly reduced in rate at room temperature. Therefore, the reserve resources of the bird would be more quickly exhausted at the high temperature than the lower, and, as a result, death would come sooner.

After the development of temperature control in young birds, other factors are more certainly of importance. At a temperature of 99° F. (37.2° C.), the body temperature would be maintained fully as well out of as in the nest. Death then would come only when the reserve sources of energy for the maintenance of the necessary physiological activities were exhausted. This is twice as long or more after 10 days of age as before 5. Possibly this may mean that the reserve supplies in the body are at least twice as ample in these older birds. At the low air temperature of 66° F. (18.9° C.), however, these older birds cannot for long maintain their normal high body temperatures. It is probably some effect of continuous low body temperature in addition to starvation that brings about death of the birds at this greater age. The physiological processes and functions are then becoming more highly developed and attuned to the stable homoiothermic condition so that they are more quickly and seriously effected when disturbed by a drop in body temperature than earlier in life before they had become so adapted.

TABLE XIX.—*Survival Time and Loss in Weight of Nestling Eastern House Wrens when Confined without Food at Different Air Temperatures*

Age at Beginning of Experiments	Temperature to Which Exposed	Survival Time	Initial Weight	Loss	Decrease of Weight
		hours	*mg.*	*mg.*	*per cent*
2 hours	98°–100° F. (36.7°–37.8° C.)	12	998	147	14.7
2 days	98°– 99° F. (36.7°–37.2° C.)	22	3424	483	14.1
11 days	98°–101° F. (36.7°–38.3° C.)	47.5	10444	4515	43.2
.....	.....	.....	.....	.....	.....
2 days	62°– 64° F. (16.7°–17.8° C.)	25	1654	23	1.4
4 days	63°– 66° F. (17.2°–18.9° C.)	26	4622	34	0.7

In 5 instances (Table XIX), weights of the house wrens were taken at the beginning and at the end of the experiments. There was a loss of weight in all cases.

The number of records are few but the results are interesting. The percentage loss in weight of those birds subjected to high temperature is considerably greater than of those subjected to low temperature. This could be explained by considering that death at the high temperature was actually due to complete starvation, while death at low temperature, even though it did not come so soon, was not due to starvation alone in the usual sense of the term, but also to the disturbance of proper physiological functioning by prolonged exposure to the low temperature. The loss in weight of the 2 birds at low temperature is really negligible. At the higher air temperatures the considerably greater percentage loss in weight of the 11-day-old bird over the 2 others is interesting. We do not have available the proportionate weights of the different organs of the body at various ages, but it is certainly obvious from mere observation that in very young birds most of the body is made up of vital organs such as the liver, heart, and particularly the digestive tract. There is very little "flesh," or muscle. This is not true in the case of birds 11 days old, for at this time the muscular tissue is much better developed, while the proportionate size of the vital organs has diminished. According to Kumagawa's work (Howell, 1928), where the percentages in weight of the different organs to the body as a whole in normal and starved conditions were determined in the dog for a 24-day fast, the greatest actual loss in weight occurs in muscle tissue and the next greatest in the fat. This is true in spite of the fact that the greatest percentage loss in weight occurs in the glandular organs. The reason for the greater decrease of weight in the bird 11 days old as compared with the younger ones is therefore clear.

NORMAL TEMPERATURE OF YOUNG BIRDS IN THE NEST

In order to determine how much the temperature of a newly hatched house wren fluctuates in the nest as a result of the intermittent brooding and absence of the adult bird, use was made of a thermocouple thermometer, similar to those used in other experi-

ments described above. This was run through the side of the nest box and nest and down the throat of the young house wren which had hatched only a few hours previously. Other thermocouples of the thread type were run across the nest, one just above the young bird, to determine the temperature to which the bird was subjected when the adult was brooding, and when she was away, and the other just beneath the young bird to determine the temperature at the bottom of the nest. The leads on these thermocouples were then run back into a blind where the temperatures were taken by means of the indicator potentiometer.

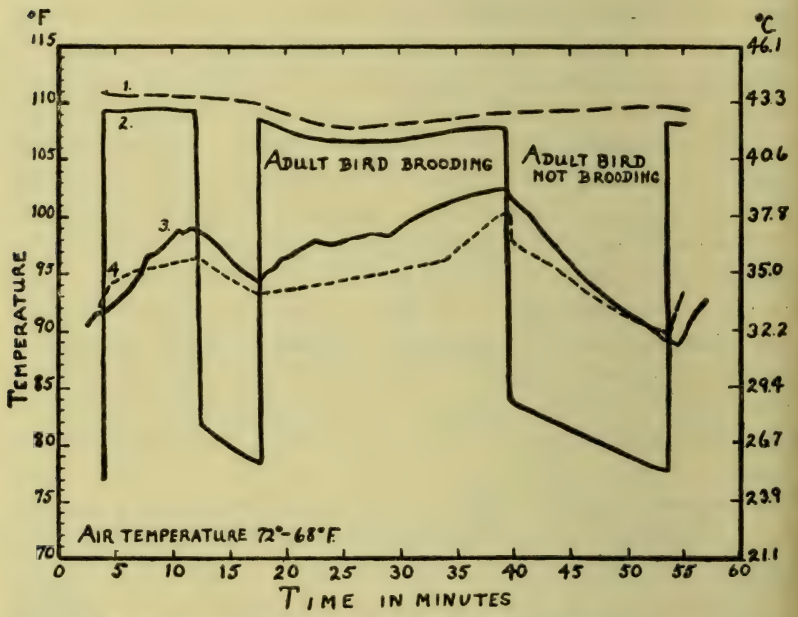


FIGURE 37.—NATURAL FLUCTUATIONS IN BODY TEMPERATURE OF A NEWLY HATCHED EASTERN HOUSE WREN UNDER NORMAL CONDITIONS IN THE NEST. 1—Body temperature of adult bird; 2—temperature at top of nest just above young bird; 3—body temperature of nestling bird; 4—temperature in bottom of nest underneath young bird.

The results of this experiment are shown by the graph in Figure 37, reproduced from our former paper (Kendeigh and Baldwin, 1928). While the adult female brooded, the temperature of the young bird rose; when she was away, the young bird's temperature

dropped. The greatest variation during this period was a drop from about 102° F. (38.9° C.) to 88° F. (31.1° C.) in a period of approximately 16 minutes.

In order to obtain some idea of the normal temperature of young house wrens in the nest at all ages before flight, use was made of mercury thermometers. Temperatures of the young in two nest boxes were taken each day at the end of several periods when the adult bird had been away (inattentive periods), and again at the end of several brooding or feeding periods (attentive periods). These 2 sets of temperatures were averaged and compared for each day. The data for one of these nests are shown in the graph (Figure 38). The greatest difference between

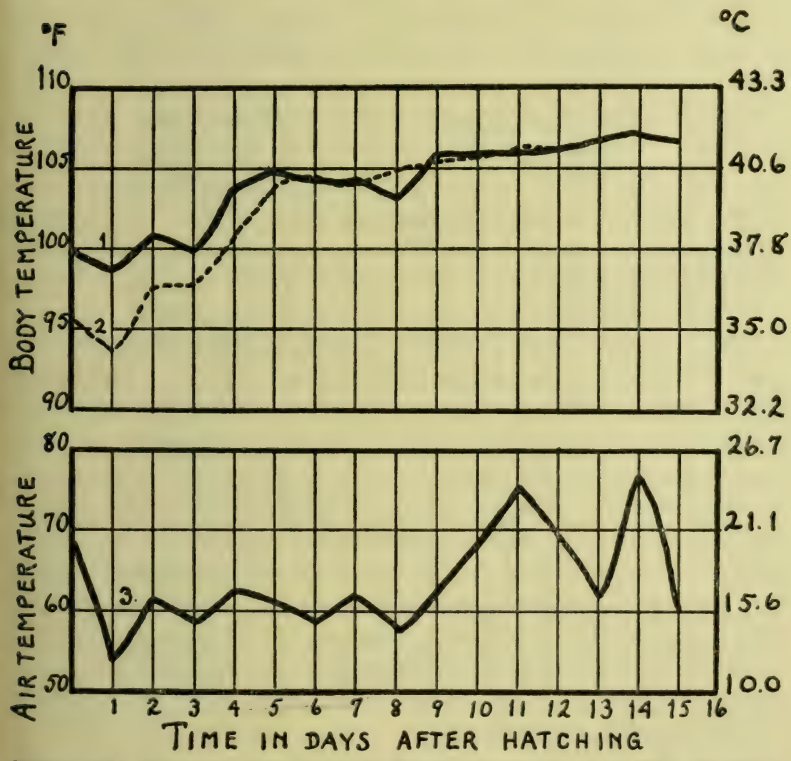


FIGURE 38.—DEVELOPMENT OF BODY TEMPERATURE OF IMMATURE EASTERN HOUSE WRENS IN THE NEST AND CORRELATION WITH AIR TEMPERATURES. 1—Temperature of the birds at end of attentive periods; 2—temperature of the birds at end of inattentive periods; 3—air temperature.

these 2 sets of temperatures, i.e., before and after brooding, occurred during the first 5 days. This is to be expected, for it is at this time that the young birds are most dependent on outside sources of heat for maintaining their body temperature. The average difference for the birds at one nest (Figure 38) for each of the first 5 days was 4.4° F. (2.4° C.), 4.9° F. (2.7° C.), 3.2° F. (1.8° C.), 2.3° F. (1.3° C.), and 3.1° F. (1.7° C.), the higher temperatures coming at the end of periods of attentiveness. For the birds at another nest the average differences for the first 5 days were 5.5° F. (3.1° C.), 7.7° F. (4.3° C.), 4.9° F. (2.7° C.), 2.0° F. (1.1° C.), and 1.4° F. (0.8° C.).

The temperature of the young birds during this early period shows a positive correlation with variations in the temperature of the air. This correlation persisted until the ninth day for the birds at one box (Figure 38). After the fifth day, there is little difference between the temperature of the young at the end of the attentive and inattentive periods. On some days it is higher in one, but on the next it may be higher in the other. This less variation in the temperature of young birds during the latter period of nest life is to be expected, since the young birds then develop a temperature control. Active brooding by the adult bird for the most part ceases when the young birds acquire this control over the body temperature.

In some cases, during the latter half of the nest period, the nestling bird's temperature is higher at the end of an inattentive period than normally at the end of an attentive one. This may be explained by a tendency of the young bird to conserve its heat, as it is quiet when the female is away, while the greater exposure of body to heat radiation when reaching for food, the greater respiration, and the ingestion of the cold mass which the female brings would tend to lower its temperature when the female is present. That the average normal variation in the young bird's temperature in the nest during the day under average environmental conditions is so small, attests to the faithfulness of the parents in caring for the young and the efficiency of their type of nest and nesting behavior.

There is a gradual increase in the body temperature of the young birds during the period in the nest. In the case of the young birds at the first nest (Figure 38), this increase was from 98.0° F.

(36.7° C.), as an average for the first day, to 106.7° F. (41.5° C.) for the last. This increase is rather uniform and persistent, and amounts to 8.7° F. (4.8° C.). This makes an average increase per day of 0.58° F. (0.32° C.). In the young at the other nest there was an increase in temperature from 96.2° F. (35.9° C.) to 106.6° F. (41.4° C.), or 10.4° F. (5.7° C.). This makes a daily increase of 0.65° F. (0.36° C.). The average daily increment in temperature for these 2 broods of young house wrens averages 0.62° F. (0.34° C.). The average temperature of these 2 sets of nestlings, 106.6° F. (41.4° C.) and 106.7° F. (41.5° C.), on the last day in the box is below the average day temperature of adult females during the summer, which we found to be 107.3° F. (41.8° C.). Stoner (1928) found a similar gradual and regular increase in the temperature of nestling house wrens until flight ability was attained, the rate of this increase averaging 0.5° F. (0.3° C.) daily.

By the use of recording potentiometers with the thermocouples placed in the bottom of the nest, continuous records of the skin temperature of young house wrens were obtained throughout the day. This has a value for comparison, since the relation between skin and body temperatures is sufficiently constant to enable us to interpret in terms of body temperature the records obtained. Even after the body becomes partly covered with feathers, the general trend in the body temperature of young birds may be followed throughout the day as long as they remain in the nest, even though the exact skin temperature is not obtained. This enables us to state the following as taken from our former paper, and this agrees in general with the findings of Kelso (1931) on desert horned larks and of Stoner (1928) on house wrens. The difference in the amount of temperature variation in the young during the daytime as compared with night is rather marked. At night, when the adult female is constantly brooding, the temperature of the young is uniform. Occasionally, there is discernible a slight lowering in the temperature from the first part of the night until early morning, but this amounts to not more than 1° or 2° F. (0.6° or 1.1° C.). During the day, on the other hand, the variation in the temperature of young birds is great, particularly during the first few days out of the shell. During the first 2 or 3 hours in the morning, after the adults begin their morning activities, the tem-

perature of the young is at its lowest point, since the adults are brooding during only a part of the time, and the air temperature is itself at or near its daily minimum. As the air temperature becomes warmer during the day, the temperature of the young also rises, so that during the early afternoon it reaches the maximum. There is then usually a decline until night. Occasionally, just before dark, before the adult has gone into the nest box to brood for the night, the temperature of the young may drop, but the drop is usually not so great as during early morning. The temperature of the young at night is lower than while they are being brooded during the day, but is generally higher than when the adult is not brooding during the day. The temperature of the young is distinctly correlated with atmospheric temperature variations, since the two closely follow each other, although that of the young birds is necessarily more fluctuating. When there is a distinct daily rhythm in the air temperature, there is also one in the temperature of the young birds; but when there is none or very little in the air temperature, the temperature of the young is more uniform. The maximum points in the air and bird rhythms come at approximately the same time.

TEMPERATURE OF EGGS AND NEST

Very little work has ever been done to determine the actual temperature of eggs during incubation, and even fewer data are available on nest temperatures. Temperature is undoubtedly one of the most important factors concerned in the incubation of eggs. This is amply realized by many authors, but it was Bergtold (1917) who particularly emphasized its importance in the study of incubation periods of different species under natural conditions.

Murray (1826) appears to have been about the first to record in print the temperature of eggs. He thrust the bulb of a small thermometer through holes drilled in the shell of hens' eggs and determined the temperature in different positions and at various depths. He concludes that the egg maintains a temperature superior to that of the external medium.

Baerensprung (1851) determined the temperature of eggs in a somewhat similar fashion, by thrusting the bulb of a thermometer through the shell of hens' eggs into the center of the yolk. He found that the temperature of eggs under incubation is not constant and is dependent on the temperature of the surroundings. No constant differences between egg and air temperatures were determined, although he did find that living eggs under incubation maintained a temperature of a few tenths of a degree above that of dead or infertile eggs. He concludes, "Zu dem Zweck dieser Untersuchung genügt der Nachweis des Factums, dass der im Ei eingeschlossene Foetus eine Eigenwärme überhaupt erzeugt."

Eycleshymer (1907) has the next contribution to the subject. He determined first the approximate temperature applied to hens' eggs by fitting a self-registering thermometer into the upper surface of a block of wood shaped to simulate an egg and placing this in the nest. He found that temperatures obtained in this way increased from 102.2° F. (39.0° C.) on the first day of incubation to 104.6° F. (40.3° C.) on the last. Actual egg temperatures were taken by fitting the egg into a tight rubber bag, immersing it in

water at 98° F. (36.7° C.), and then thrusting a thermometer through the shell into the center of the yolk. The hen's temperature was taken by placing a thermometer in the groin for about 5 minutes. He found that the egg temperature averaged lower than that of the hen, and was approximately 101° F. (38.3° C.) for the first week, 102° F. (38.9° C.) for the second, and 103° F. (39.4° C.) for the third. In order to obtain these temperatures in artificial incubation, the incubator had to be run at 102°–103° F. (38.9°–39.4° C.) for the first half, and 103°–104° F. (39.4°–40.0° C.) for the latter half.

FLUCTUATION IN EGG TEMPERATURE UNDER EXPERIMENTAL CONDITIONS

In order to study the possible variations in the temperature of the eastern house wren's eggs, the rapidity of response to variations of external temperature, the degree of approximation to external temperature, and similar problems, a study was first made of the temperatures of eggs under controlled conditions. Temperatures were taken with the indicator potentiometer and thermocouple. Moran (1925) in his studies used thermocouples to obtain the temperature of hens' eggs.

The thermocouple thermometer used in our work was made as small and delicate as possible, well insulated so that it was certain that only the temperature at the tip was recorded, and thrust into the egg. A small opening in the shell was made by a delicate egg drill, and the thermocouple thrust just within the membrane that lines the base of the air space at the large end of the egg. This air space was not punctured, but the thermocouple was approximated to it so that the egg contents would, thereby, be less disturbed. The thermocouple was not in the air space or in the yolk mass but rather at one side of the latter. In some instances, the tip was close to the inside of the shell on the other side of the egg from which it entered, at other times at various depths within the egg, and still in other instances less than half way through. In all instances, however, the thermocouple lay close to the embryo although not actually penetrating it. Thus the egg temperature was determined rather than that of the embryo, but, undoubtedly, this means very little discrepancy and may be disregarded.

In this experimental work no difference was noted in the response of the egg as determined from the different positions of the thermocouple. The opening left around the sides of the thermocouple was closed by means of collodion which quickly dried and hardened after being applied. The egg with its thermocouple was fastened firmly on cotton batting in a small open box so that it could be shifted about without danger of the thermocouple's harming the egg. To get the air temperature, another thermocouple was fastened in the box close to the egg. The two thermocouples when later compared at the same air temperature gave identical readings.

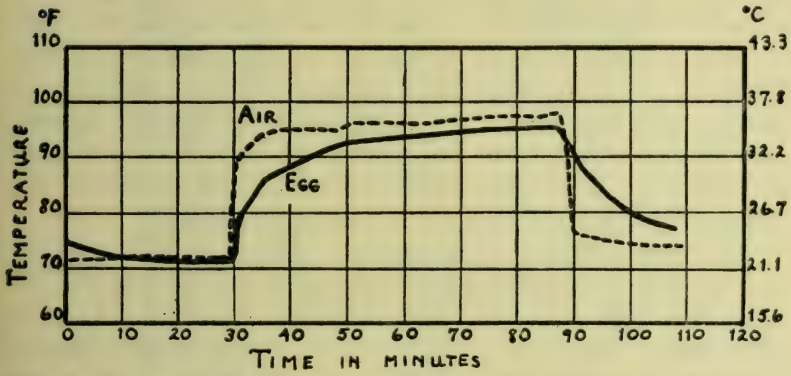


FIGURE 39.—EFFECT OF VARIATIONS IN AIR TEMPERATURE ON THE TEMPERATURE OF THE EGG OF THE EASTERN HOUSE WREN UNDER EXPERIMENTAL CONDITIONS.

Figure 39 represents a typical result obtained with all 5 eggs used, when the eggs were first exposed to room temperature directly after the few minutes involved in the placing of the thermocouple, and then placed in an incubator, after which they were again exposed to room temperature. Readings of temperature were taken every few minutes. At the termination of each experiment, the thermocouple was withdrawn from the egg, and, on examination, the embryo was found still to be alive.

The temperature of the egg responds very quickly to variations in the temperature of the air, both rising and falling, although there is in all cases a very perceptible lag. If given time, however, the egg approximates the air temperature and frequently drops

below this. This is true both at room temperatures and incubator temperatures.

In order to study more accurately the exact relation between egg and air temperatures, use was made of another instrument (Plate II–B). This is described in the first section of this paper (page 21). The difference in potential between 2 thermocouples is measured by means of a sensitive galvanometer, and this is calibrated into degrees Fahrenheit. One thermocouple was placed approximately half way through the egg, while the other was held about an inch away to get air temperature. The whole was then placed in a covered dark box to avoid possible error from air currents and also from the warming of the air by the observer's presence within a few feet. Accuracy of recording by this means is greater the smaller the difference in thermoelectric potential between the 2 thermocouples; the accuracy here attained was within a few hundredths of a degree, since the difference between air and egg temperatures amounted in no instance to more than 1.0° F. (0.6° C.). The results obtained are not voluminous but are presented in Table XX for preliminary discussion.

Two determinations of temperature were made with each egg, one at a low, the other at a high temperature. In all instances, the eggs were held under the same conditions for 2 or 3 hours or even longer, until it was certain that the relation between egg and air temperatures had become stabilized. As before, at the end of each experiment the egg was opened and the embryo ascertained to be alive. The differences between egg and air temperatures determined at the lower degrees are more satisfactory than those at the higher. This is because, at the higher incubator temperatures, there was some continual fluctuation in air temperature amounting to a few tenths of a degree. At the lower temperatures, there were no fluctuations in air temperature discernible.

In the case of eggs of less than 10 days' incubation, temperatures were below those of the surrounding air. The explanation of this difference lies probably in the cooling effect of water which is being continuously evaporated from the surface of the egg. The average loss in weight of house wrens' eggs in the nest from the first day of steady incubation until the last has been determined by daily weighings. For 22 eggs distributed in 4 sets through the summer, this amounts to 13.3% of the original weight. This

TABLE XX.—*Relation between Temperature of Eggs and That of the Surrounding Air*

Species	Number of Days' Incubation of Egg	Air Temperature	Relative Air Humidity *per cent*	Difference between Egg and Air Temperature	Air Temperature	Relative Air Humidity *per cent*	Difference between Egg and Air Temperature
Eastern house wren	0	69° F. (20.6° C.)	88	—0.2° F. (—0.1° C.)	93° F. (33.9° C.)	45	—0.2° F. (—0.1° C.)
"	2	63° F. (17.2° C.)	90	—0.3° F. (—0.2° C.)	98° F. (36.7° C.)	38	—0.2° F. (—0.1° C.)
"	3	68° F. (20.0° C.)	86	0.0° F. (0.0° C.)	96° F. (35.6° C.)	47	—0.4° F. (—0.2° C.)
"	5	67° F. (19.4° C.)	81	—0.6° F. (—0.3° C.)	98° F. (36.7° C.)	67	—0.6° F. (—0.3° C.)
"	7	70° F. (21.1° C.)	77	—0.1° F. (—0.1° C.)	.....	.....	.....
"	10	69° F. (20.6° C.)	69	—0.1° F. (—0.1° C.)	97° F. (36.1° C.)	67	+0.4° F. (+0.2° C.)
"	10	67° F. (19.4° C.)	74	+0.1° F. (+0.1° C.)	99° F. (37.2° C.)	64	0.0° F. (0.0° C.)
"	12	70° F. (21.1° C.)	89	+0.2° F. (+0.1° C.)	98° F. (36.7° C.)	58	+0.8° F. (+0.4° C.)
Eastern robin	7	64° F. (17.8° C.)	77	—0.2° F. (—0.1° C.)	99° F. (37.2° C.)	67	—0.6° F. (—0.3° C.)
" "	12	65° F. (18.3° C.)	66	+0.2° F. (+0.1° C.)	99° F. (37.2° C.)	47	+1.0° F. (+0.6° C.)
Eastern song sparrow	3	65° F. (18.3° C.)	81	—0.2° F. (—0.1° C.)	98° F. (36.7° C.)	31	—1.0° F. (—0.6° C.)
"	9	71° F. (21.7° C.)	89	—0.1° F. (—0.1° C.)	96° F. (35.6° C.)	53	—0.2° F. (—0.1° C.)

means that, on the average, 16.3 milligrams were lost per day per egg. The greatest proportion of this loss in weight is due to water evaporated. The metabolism of the embryo in the egg causes some small amount of heat production, but with the relatively large surface for heat loss in proportion to the volume of the egg, this excess heat is rapidly dissipated. The temperature of the egg in relation to the temperature of the air is determined by the balance between the amount of heat received, the amount produced, and the amount dissipated.

As the embryo becomes formed in the egg and the yolk is absorbed and transformed into active protoplasm, the amount of material exhibiting metabolism and heat production increases. This causes a disturbance in the balance originally set between heat production and heat loss, with the consequence that the egg assumes a higher relative temperature. This is shown in the table, although it amounts to only a few tenths of a degree (F.). In the case of a house wren's egg of 12 days incubation, the temperature was maintained at 0.2° F. (0.1° C.) above that of the air. Young house wrens recently hatched (approximately 13 days after the beginning of steady incubation) are able, as we have shown, to maintain a body temperature only 0.4° F. (0.2° C.) above the corresponding air temperature. There is consequently an inherent tendency for the embryo (and nestling) to increase the body temperature, at first very slightly, from the first days of incubation entirely through the developmental period until it is ready to leave the nest.

All the work on the temperature of hen's eggs, particularly that of Eycleshymer (1907), indicates a temperature above that of the surrounding air (or water) for the entire period of incubation. Some preliminary work of our own on hens' eggs in an incubator confirms this. In house wrens' eggs, a temperature of the egg below that of the air was obtained for the early days of incubation. It is probable here that a difference in the size of the eggs, together with a difference in the thickness of the shell, are important. The egg of the eastern house wren or eastern robin is much smaller than that of the domestic fowl, hence the amount of surface exposed for heat dissipation is much greater in proportion to the volume of the egg concerned with heat production. Eycleshymer also found an increase in the temperature of the hen's egg (2.0° F.

[1.1° C.]) during incubation, which was considerably more than in the case of either the eastern house wren, eastern song sparrow, or eastern robin. This may be correlated with the degree of development which the chick attains before hatching, which is greater than in an altricial species.

RESISTANCE OF EMBRYOS TO HIGH TEMPERATURE

Poultry raisers are usually advised not to allow the incubator temperature to rise above 105° F. (40.6° C.), as this would greatly decrease the number of eggs that would hatch. A temperature of 103° F. (39.4° C.) is usually the highest average running temperature advised. With higher temperatures, abnormal chicks bearing monstrosities of various sorts are likely to be produced. Lippincott (1921) states that when the incubator is run at temperatures between 103° F. (39.4° C.) and 108° F. (42.2° C.), 90% of the embryos have abnormalities in their nervous systems by the 72nd hour. Likewise when the incubator is run at a temperature too low, as between 94° F. (34.4° C.) and 101° F. (38.3° C.), 67% of the embryos have abnormal nervous systems by the 72nd hour. Lamson and Kirkpatrick (1918) place 110° F. (43.3° C.) as the upper thermal limit at which eggs will hatch, but say that at 112° F. (44.4° C.), eggs may be kept for 15 hours at certain stages and still the strongest embryos will hatch. This is, however, approaching the very highest limit at which development will occur, and is, therefore, much too high for practical work in artificial incubation.

In our work we have run a series of experiments with house wrens' eggs at different temperatures to determine the effect on later development (Table XXI). Eggs were taken from the nests when they had been incubated normally for 5 or 7 days and placed in the same temperature apparatus in which we studied the resistance of older birds to high and low body temperatures (Plate III), but it was possible to keep only 2 eggs at each temperature. After an hour they were replaced in the nests and left to the normal care of the adult birds. Two sets of controls were used, 4 eggs left in the nests without disturbance in order to get a check on the normal time of hatching, and 4 eggs kept in the

temperature apparatus similarly to those experimented with, but at air temperatures of 99° F. (37.2° C.) and 101° F. (38.3° C.), which approximate normal temperatures in the nest. All of these air temperatures were maintained fairly constant. The actual egg temperature undoubtedly approximated very closely the air temperature. The time of hatching of the eggs in the nests was then noted.

TABLE XXI.—*Effect of Exposure to High Air Temperatures on the Hatching of the Eastern House Wren's Eggs*

Number of Eggs Used	Air Temperature to Which Egg Exposed for One Hour	Number to Hatch	Number Failing to Hatch
4	In Nest (Control)	3	1 (Infertile?)
2	99° F. (37.2° C.)	2	0
2	101° F. (38.3° C.)	2[1]	0
2	106° F. (41.1° C.)	1	1
2	111° F. (43.9° C.)	1	1
2	114° F. (45.6° C.)	0	2
2	116° F. (46.7° C.)	0	2

[1]One pipped, then died.

All of the control eggs, except 1 which was probably infertile, hatched at the normal time, both those left undisturbed in the nest and those that had been placed in the temperature apparatus. This indicates that the disturbance and the handling of the eggs in themselves could be eliminated from the consideration of the results obtained, and any effect could be attributed directly to the high temperature. Of the 2 eggs subjected to 106° F. (41.1° C.), 1 hatched on normal time, the other did not hatch at all. On examination, the embryo was found to have been killed at the time of the experiment. Of the 2 eggs subjected to 111° F. (43.9° C.), 1 hatched at the normal time, the other was found to have been killed at the time of the experiment. Both of the embryos subjected to 114° F. (45.6° C.) and 116° F. (46.7° C.) were found to have been killed at the time of the experiment. The conclusion to be drawn from this is that there is a 50% likelihood that egg embryos partly incubated will survive an hour's subjection to air temperatures of 106° F. (41.1° C.) or 111° F. (43.9° C.),

but that they will all be killed at 114° F. (45.6° C.) or 116° F. (46.7° C.). The eggs that hatched did so at the time expected of undisturbed eggs, so that no delay was caused as was the case with eggs subjected to low temperatures, which will be discussed later.

It is interesting that in the case of eggs, young birds, and adults of the house wren, body temperatures between 114° F. (45.6° C.) and 116° F. (46.7° C.) were absolutely fatal. Age seems not to be a factor, but this latter temperature appears to be the upper lethal point for the bird at all stages of development. The amount of variation in this limit is relatively small. Lower temperatures can be endured, but as soon as the body temperature reaches this high point, death is almost certain and usually immediate. That this holds true for the youngest as well as the oldest stages would indicate that some fundamental reactions are disturbed and that these probably lie in the physical or chemical nature of the protoplasm of the cells itself—rather than a possible disturbance in the functioning of some organ, although this may also occur.

RESISTANCE OF EMBRYOS TO LOW TEMPERATURE

Just how low a temperature of the air and egg the embryo in the egg is able to resist was not determined by our laboratory experiments, except that temperatures down to 63° F. (17.2° C.) were readily resisted, although the exposure time was brief. Edwards (1902) found that in eggs of the domestic fowl there may be slight development of the embryo at air temperatures even as low as 68° F. (20.0° C.). The temperature of the egg, as we have shown, closely approximates that of the air. One house wren's nest containing 7 eggs deserted by the adults dropped in air temperature to 52° F. (11.1° C.) on the following night. The eggs, which had 2 days' incubation, were not removed until the following afternoon, when they were placed in an incubator. When opened a few hours later, 5 out of the 7 were still alive. In some embryological work, house wrens' embryos have been removed and kept in saline solution at temperatures below 75° F. (23.9° C.) for more than 7 hours before death resulted. Lamson and Kirkpatrick (1918) state that hens' eggs from strong stock will stand 4 to 5 hours exposure at 50° F. (10.0° C.) after the

first 24 hours of incubation. The length of this exposure may be increased without harmful results up to 15 hours on the tenth to twelfth days. After the 17th day, continued exposure at this air temperature for more than 6 hours kills the embryo. Moran (1925) studied the microscopic nature of the contents of fresh hens' eggs as affected by various low temperatures. He measured the actual temperature of the eggs by means of thermocouples. He states in the summary that below 32° F. (0° C.) the eggs quickly lose their fertility and that at approximately 21.2° to 19.4° F. (—6.2° to —7.4° C.) the embryo of the egg immediately dies. He states also that there is an optimum temperature for fresh fertile eggs in the region of 46.4° to 50° F. (8.0° to 10.0° C.), at which temperature they maintain their fertility for the longest space of time. Advisers in poultry production commonly say that fresh eggs to maintain their vitality the longest should be kept at air temperatures around 50° F. (10.0° C.) (Atwood, 1917; Lamson and Kirkpatrick, 1918). Lipschutz and Illanes (1929) found that normal chicks developed after eggs had been exposed to 21.2° to 24.8° F. (—6° to —4° C.), but not to 14.0° F. (—10.5° C.). Dougherty (1926) in extensive experiments with hens' eggs found that exposure of fresh eggs to 28° to 32° F. (—2.2° to 0° C.) for 3 successive nightly periods of 14 hours each plus a continuous period of 38 hours did not result in any significant reduction in the percentage of chicks hatched. However, an exposure to these same temperatures for 4 successive nights plus a continuous period of 38 hours did result in a reduction in the percentage of chicks hatched. All of this evidence tends to show that egg embryos can withstand body temperatures even lower than can nestling birds or adults.

This greater resistance of embryos to low temperature is of significance. If we compare our above given data on the lower lethal body temperatures of adult birds and young birds (about 71° F. [21.7° C.] for adults to 47° F. [8.3° C.] for young nestlings) with this evidence for eggs, we find with increasing age a gradual decrease in resistance. The younger the organism is, the lower the body temperature that can be tolerated without causing death. Likewise the younger an animal is, the more exactly does it react like a cold-blooded animal. Many cold-blooded animals are not killed by low temperature except when their body fluids

become frozen, and as these are naturally rich in salts, this point may not be reached for several degrees below the freezing point of water. Living protoplasm that has had most of its water removed can withstand an extremely low temperature. Apparently with the development of a temperature control mechanism for the maintenance of a constant uniform high body temperature, this ability of the protoplasm to resist low temperature has been sacrificed—or, it may be that in the course of evolution the warm-blooded condition developed because the protoplasm lost the ability to withstand low temperature. At any rate, the greater resistance of eggs and young birds to low body temperature is another proof of the fact that, in their ontogenetic development, birds pass from a low cold-blooded to a high warm-blooded state.

A series of experiments was undertaken to ascertain what effect the exposing of house wrens' eggs to low air temperature at different stages of incubation and for different lengths of time would have on their hatching under normal conditions. Eggs at the desired stages were removed from the nest and placed in a room temperature of 60° to 70° F. (15.6° to 21.1° C.) and a humidity between 80% and 90%. Here they were left for the desired interval and then returned to the nest. Note was kept as to whether or not they hatched, and, if so, how long after the control eggs, which had not been removed. The data so far accumulated are not extensive but permit compilation and analyzing in the manner indicated in Table XXII.

In Table XXII the expression "failure to hatch" means that the exposure was a fatal one, and that later examination of the embryo in the egg showed conclusively that no life remained.

TABLE XXII.—*Effect on Hatching of the Exposure of the Eastern House Wren's Eggs for Various Lengths of Time to Air Temperatures of 60° to 70° F. (15.6° to 21.1° C.) and Relative Humidities of 80% to 90%*

Hours Exposure	1 to 8 Days Incubated				11 to 13 Days Incubated			
	Number of Eggs Used	Number That Failed to Hatch	Number That Hatched	Hours Delay in Hatching	Number of Eggs Used	Number That Failed to Hatch	Number That Hatched	Hours Delay in Hatching
3–16	11	1	10	6.9	5	0	5	0
20–48	11	10	1	6.0	5	4	1	36

This examination of the embryos brought out the interesting fact that some embryos that did not hatch were not killed at the time of exposure to the low air temperature but died at some later period. The exposure, therefore, tended to lower the vitality and general resistance of the embryo even when death did not actually take place at the time. This is further brought out by the evident delay of hatching in many instances of embryos which did live. The normal time of hatching is indicated by the control eggs. The number of hours delay in hatching is the number of hours left after the length of exposure has been subtracted from the number of hours intervening between the hatching of the control eggs and those on which the experiment was made. Apparently the subjection of the embryo to a low air temperature even for a relatively brief portion of the incubation period has the effect of greatly slowing the rate of complete development.

Even though the general tendency is that the younger the bird, the lower the temperature it can withstand, eggs in earlier stages of incubation were, on the contrary, more delayed by this exposure than were the later stages. On the eleventh to thirteenth days of incubation, exposure for 16 hours or less to an air temperature of 60° to 70° F. (15.6° to 21.1° C.) did not delay the normal time of hatching after allowing for the time that the eggs were out of the nest. However, it must be remembered that we are not here dealing with resistance to the lethal action of extremely low temperature, as we were above, but with retardation of developmental processes. Exposures of 20 hours or more were fatal at all stages, with 2 exceptions. One egg, kept out of the nest for 24 hours on the eleventh day of incubation, hatched, but not until after a delay of 36 hours. Another egg, kept out for 30 hours on the sixth day of incubation, hatched, and this only 6 hours late. This is the longest time that we have succeeded in exposing any partly incubated egg to low temperature and have it hatch.

This evidence, together with that from the literature, shows that fresh eggs may withstand a lowering of their temperature nearly to freezing for a short period of time; and that partly incubated eggs can withstand lowering of their temperature to a medium degree for as long as 16 hours, but that this may cause a delay, except during very late stages of incubation, in the time of their hatching.

FLUCTUATION OF EGG TEMPERATURE IN THE NEST

After studying the possibilities for the variation of the temperature of the egg without the consequent death of the enclosed embryo, it is important to inquire concerning the normal fluctuations in the temperature of eggs in the nest under natural conditions. By the use of thermocouples this was possible without disturbing the natural behavior of the adult bird. It is well to bear in mind throughout all discussion of work done with the eastern house wren under natural conditions, that we are here dealing with an unusual species of bird—unusual in the sense that it permits maximum disturbance with minimum alteration of normal and natural behavior. We may approach its nests, remove eggs or young, alter the location of nesting boxes, or even shift the nest from one type of box to another, or make drastic changes in other ways, all with the assurance that when we have finished, the adult birds will be back again, at least within 10 minutes, frequently within 2 minutes, and behaving as if nothing had happened. This has been checked over and over again after all sorts of disturbance. However, in studying natural conditions, the nest was disturbed as little as possible. We feel then, that when we say that our results and information are for normal natural conditions, they should be accepted at this value.

In order to obtain the temperature of eggs in the nest, a delicate thermocouple thermometer was thrust into the egg as before, so that in practically all cases the functional tip of the thermocouple lay next to the embryo on the upper side of the egg, without puncturing or injuring the embryo. At the end of the experiment this was always checked by examination for signs of life. The egg so treated was returned and placed in the middle of the set at the bottom of the cavity so as to be in an average position. The thermocouple wires were run from the egg through a small hole made in the bottom of the nest and nest box. This hole was then plugged so that no circulation of air through it was possible. The wires were thence run into a small movable blind immediately back of the box, where the temperature readings were taken. One thread thermocouple was also run across the nest just above the eggs so as to obtain the temperature applied by the sitting bird,

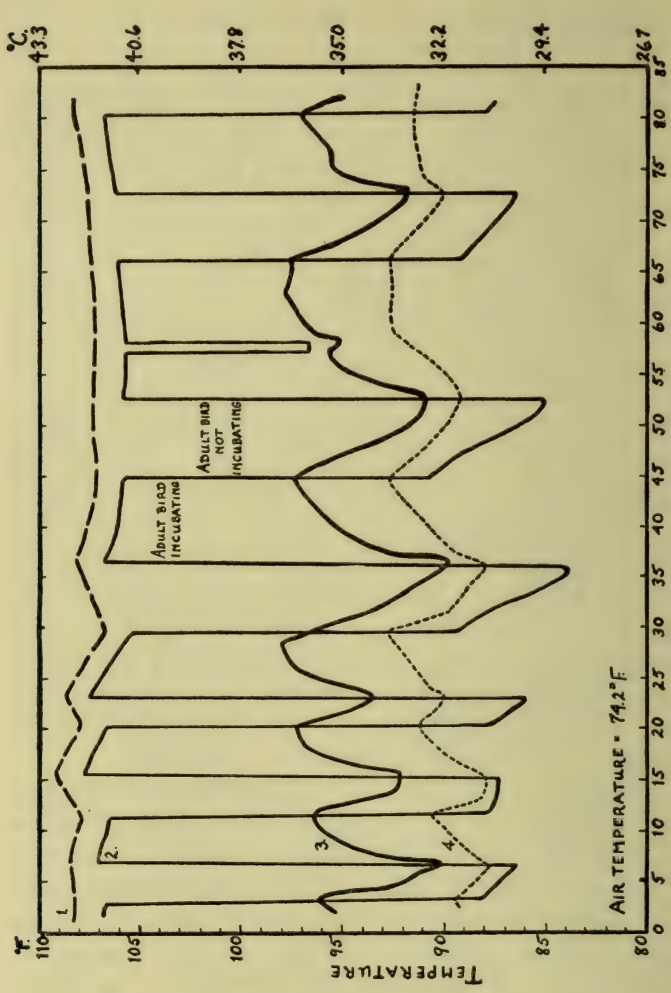


FIGURE 40.—NATURAL FLUCTUATIONS IN TEMPERATURE OF THE EASTERN HOUSE WREN'S EGG UNDER NORMAL CONDITIONS IN THE NEST. 1—Body temperature of adult bird; 2—temperature at top of nest just above egg; 3—egg temperature; 4—temperature in bottom of nest beneath egg.

and another was stretched across the bottom of the nest just under the eggs.

Figure 40 gives very typical results and illustrates well the normal fluctuation in the temperature of eggs in the nest. Here the body temperature of the adult bird is, for comparison, interpolated. During the periods of attentiveness, when the bird is on the nest incubating, her body temperature gradually decreases. The temperature applied to the top surface of the eggs, which is

actually the skin temperature of the under surface of the body, decreases at a corresponding rate. However, the temperature applied to the eggs is so much higher than the temperature of the egg itself that this slight reduction does not in the least prevent a gradual rise in the temperature of the egg. If the attentive period is short, that is, less than about 5 to 10 minutes, the egg temperature may rise continuously as long as the bird remains on the nest. When the attentive periods are longer, the egg temperature at length comes to an equilibrium and may then remain more or less constant, which is, for instance, the condition at night. The average maximum egg temperature during the daylight hours, as determined from studies over 26 attentive periods during the day, is 98.5° F. (37.0° C.). The highest single record obtained was 101.5° F. (38.6° C.). When the bird is on the nest for periods shorter than usual, the egg does not warm up as much as when the bird remains longer, but an unusually long incubating period does not necessarily mean an unusually high egg temperature, as already stated. The body temperature of the bird at night and hence the temperature applied to the eggs, is less than during the day, but as the bird then sits more steadily the equilibrium of egg temperature is about the same as during the day. There is enough lag in the response of the egg temperature to variations in applied air temperature so that slight movements or turnings of the bird on the nest do not materially affect the egg's temperature, but when the bird is more uneasy or actually leaves the nest for brief intervals, the temperature of the egg decreases.

During periods of inattentiveness, when the adult bird is entirely away from the nest, the temperature of the egg falls continuously. This fall does not terminate at some equilibrium point as during the periods of attentiveness, but will continue to fall until the general air temperature is reached. This seldom occurs naturally, however, because the return of the bird after a few minutes starts the warming process all over again. The average minimum temperature that the eggs reached during 26 inattentive periods was 93.1° F. (34.0° C.), and the lowest natural record we have is 89.0° F. (31.7° C.), The normal fluctuation of egg temperatures in the nest is, therefore, 5.4° F. (3.0° C.).

The temperature of the air is important also. During cold weather, the egg temperature drops more rapidly than during warm

weather. But there is some compensation for this, since attentive periods tend to average longer during cool weather while inattentive periods average shorter. Thus the egg is maintained in about the same range of temperature under all conditions.

TEMPERATURE OF INCUBATION

It is desirable to know the optimum temperature of incubation for comparative purposes among different species of birds in order that correlations with ontogenetic and phylogenetic development, lengths of the incubation period, structure of the nest, habitat of nest, and general nesting behavior of the birds may be made. In the present literature one can find reliable data on this point for only the domestic fowl, other domesticated or semi-domesticated birds, and a few game species. The general opinion is that temperatures ranging from 100° to 103° F. (37.8° to 39.4° C.) are best for these species, particularly the domestic fowl. These temperatures generally refer to those taken by means of a thermometer hung in an artificial incubator with the bulb close to the eggs but not touching them.

Eycleshymer (1907) found with domestic fowls higher egg temperatures in the latter part of the incubation period than in the first part, and attempts to explain this on the basis of a higher body temperature of the incubating hen. According to the careful work of Simpson (1911), no such increase in the body temperature of the incubating hen occurs during the period of incubation. If it be found that the temperature applied to eggs in natural nests increases with the advance of incubation, this will probably be due to the disappearing of feathers on the ventral side of the body, these either being plucked out by the bird or lost in some other manner. With the house wren, these belly and breast feathers are lost during the first egg laying period of the season. Female birds of this species caught before any eggs are laid have the ventral side of the body covered with feathers; other birds caught midway of the egg laying period have already lost many of these feathers; but the skin of the belly does not become entirely bare until about the time that the last egg is laid. As a result, the records that we have obtained show that during the first egg laying period there is a very marked and noticeable increase in temperature

applied, but that by the time the last egg is laid there is no further increase. The temperature applied to house wrens' eggs in the nest does not increase during the course of the incubation period (pages 75–76).

One of the principal themes in Bergtold's discussion of the incubation periods in birds (1917) is not correct, since he states that the optimum incubation temperature for any species is the temperature of the incubating parent. The average body temperature of the incubating adult female house wren is 106.3° F. (41.3° C.), but this temperature becomes greatly lowered as the heat is transferred from inside the body to the skin, to the nest, and finally into the egg itself. The embryo itself is not subjected to 106.3° F. (41.3° C.), hence this cannot be its optimum temperature for incubation. The temperature of incubation must be the temperature of the egg itself.

In order to study this problem of the correct incubation temperature, we have, during the last 5 years, been attempting to incubate the eggs of species of wild birds artificially. This we are doing in a small electric incubator with thermostatic control, good ventilation, and with other conditions favorable.

The eggs of certain species, such as those of the domestic pigeon, have been carried through from a fresh condition until the hatching of perfectly normal young birds. This was at a temperature of 102° F. (38.9° C.), as measured by a mercury thermometer suspended from the top, so that the bulb was at the level of the eggs, fairly close, but not touching them.

In addition to the domestic pigeon, we have tried eggs of the eastern house wren, catbird, eastern robin, eastern phoebe, northern crested flycatcher, cedar waxwing, and killdeer, but most of the experimentation has been done with eggs of the eastern house wren. We desired first to ascertain optimum conditions for the incubation of the house wren's eggs, and then to vary different factors in turn, to determine the effect produced on the development of the embryo—all to correlate with the conditions found in the natural nests of the species. Turning of eggs, cooling of eggs daily, ventilation, and humidity are factors involved, in addition to the temperature, so the problem is no small one.

Temperatures of 103° F. (39.4° C.) and 104° F. (40.0° C.) were tried first with no success at all. At a temperature of 102° F.

(38.9° C.), embryos could be started to develop, or if the eggs were put into the incubator after a week or so of natural incubation in the nest, they could be carried through to hatching; but no fresh eggs could be hatched at this temperature, as the embryo invariably died sooner or later. At a temperature of 101° F. (38.3° C.), 1 house wren's egg, placed in the incubator when fresh, hatched 14 days later. Other embryos placed in the incubator at the same time died, although in some instances not until the eggshell was already pipped. When constant temperatures were used at 99.5° F. (37.5° C.), 98.0° F. (36.7° C), and 97.5° F. (36.4° C.), only 1 out of 18 eggs hatched, although several others were brought up to the last day. The best success that we have thus far attained has been by starting the development of embryos with the incubator temperature at 95° F. (35.0° C.), then after a day raising it to 97° F. (36.1° C.), and finally to 100° F. (37.8° C.) for most of the period. The humidity was held at about 64%, the eggs were turned once a day until the last 3 or 4 days, and were cooled about a half hour during each of the first 4 days. Under these conditions approximately half the eggs hatched. A more detailed report on this study of artificial incubation will be presented when the study is completed. All that it is desired to show here is the indication that the house wren's eggs are best developed at a temperature of 100° F. (37.8° C.) or below, rather than above, and that a lower temperature is required during the early part of the incubation in order to begin the development, than is desirable to continue the development through the later stages. In natural nests of the house wren, the first eggs laid receive only a little incubation during the early days, but as succeeding eggs are laid, more and more heat is applied to them daily until the last egg is laid, when normal incubation begins in earnest. The first eggs laid receive a gradual increase in heat daily to initiate their development, but the last egg apparently starts its development at the highest degree.

In the data on egg temperatures given in the preceding pages, the actual internal temperature of the house wren's eggs in the nest was found to fluctuate under natural conditions between the limits of 98.5° F. (37.0° C.) and 93.1° F. (34.0° C.). This temperature is even lower than that at which the eggs were maintained artificially in the incubator. Because of the temperature

fluctuation of the house wren's egg in the nest, the difficulty of stating any one degree of temperature as the optimum is obvious. It is quite possible that the house wren's embryo develops best in a fluctuating temperature; and that for normal development such fluctuating temperatures rather than constant ones are required. It is very desirable that more research on this point be conducted.

FLUCTUATION IN TEMPERATURE OF THE NEST

The temperature at the top of a house wren's nest, which for our purpose may be considered the level of the top surface of the eggs, undergoes greater fluctuations than that of any other part (Figure 40). This is, of course, to be expected, since it receives the skin temperature of the female while she is incubating and is the most exposed portion of the nest when she is away. When the female leaves, the temperature at the top of the nest drops precipitously at first. Then, as the temperature of the nest falls, because of a circulation of cold air that comes into the nest box from the outside, the temperature of the top of the nest continues to drop more slowly, the rapidity and extent of the drop being dependent on the difference between the temperature of the nest and the general temperature of the atmosphere. It is, therefore, greatest when the atmospheric temperature is lowest. The decrease in nest temperature gradually slows down as the atmospheric temperature is approached more and more closely, but the return of the adult bird to brood long before it reaches this point checks its downward progress.

The bottom and the back of the nest are the most thermostatic portions. They fluctuate in temperature as the adult bird is on or off, but the fluctuations are much smaller than those of the other portions of the nest. When the bird is sitting on the eggs, the bottom of the nest beneath the eggs receives less heat, of course, than does the top, and so warms up more slowly. However, when the sitting bird leaves, it is the portion of the nest least exposed and so cools off less rapidly than any other part. Also the cluster of eggs not only radiates heat in all directions but forms pockets between the individual eggs where the ready circulation of cold air is greatly hampered. The house wren's nest, in addition, is usually well lined with cast-off chickens' feathers, so that very much of the

heat is conserved. The temperature of the bottom, together with the back of the nest, is, therefore, higher than that of any other portions during the time that the adult bird is absent. The egg temperature is usually above the bottom temperature at first, but approaches it more and more closely the longer the incubating bird remains away, and may eventually become lower. If the nest is deserted for a sufficiently long time, all parts of the nest including the eggs settle down to about the same temperature, which is that of the outside air.

The temperature at the side of the nest is obtained by placing thread thermocouples about midway between the level of the top and the lower surfaces of the eggs. The sides of the nest we distinguish from the front and back with reference to the entrance of the nest box. The sides of the nest are rather variable in their fluctuations of temperature, due largely to the different positions assumed by the adult bird as she sits on the eggs; but the bird usually sits facing the front. The temperature of the sides ordinarily averages several degrees below the bottom temperature, but may occasionally fluctuate above the latter. The temperature of the sides rises when the bird is on and falls when she is off, but the extent of the fluctuation is usually not great.

The temperature at the front of the nest is also variable, occasionally being higher than the bottom but usually averaging lower, both when the bird is on and when she is off the nest.

As illustrated in Figure 41 (Table XXIII), after the adult bird has been incubating, the temperature gradients all begin at the top level of the eggs from the skin of the bird and project downward and outward in all directions, and from the bottom to the sides. After the bird is gone, all the gradients begin at the bottom and back of the nest and project upward and around and probably diverge as they get above the nest cavity. This general scheme varies slightly, dependent on the structure and shape of the nest, on the length of time that the adult has been present or away, and also on the position of the bird in the nest, but should hold for average circumstances. The fact that the eggs maintain a higher temperature, at least for a time, than any part of the nest when the adult bird is away means that some heat is continuously being radiated from their surfaces in all directions. This complicates the gradient relations to some extent, particularly the one between

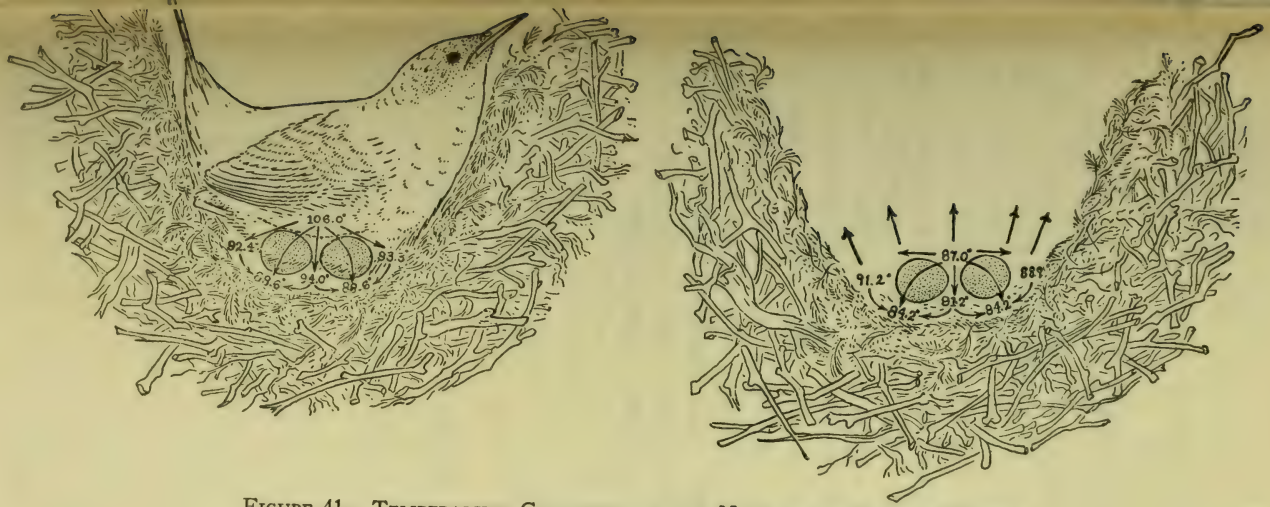


FIGURE 41.—TEMPERATURE GRADIENTS IN THE NEST OF AN EASTERN HOUSE WREN DURING THE PERIOD OF ATTENTIVENESS WHEN SHE IS ON (LEFT), AND DURING THE PERIOD OF INATTENTIVENESS WHEN SHE IS OFF (RIGHT). (*Drawn by Dr. James Manson Valentine.*)

TABLE XXIII.—*The Temperature of Different Parts of the Nest of the Eastern House Wren, both when the Bird Is Incubating and when It Is off the Nest*

	Top of Nest	Bottom of Nest	Side of Nest	Front of Nest	Back of Nest
Bird on.....	106.0° F. (41.1° C.)	94.0° F. (34.4° C.)	88.6° F. (31.4° C.)	93.3° F. (34.1° C.)	92.4° F. (33.6° C.)
Bird off.....	87.0° F. (30.6° C.)	91.2° F. (32.9° C.)	84.2° F. (29.0° C.)	88.9° F. (31.6° C.)	91.2° F. (32.9° C.)

the bottom of the nest and the top of the eggs. The gradient is probably very slight until the upper level of the eggs is reached and then falls rapidly. These data and averages are for several hours' records at 4 different nests.

The interrelations of nest, air, eggs, skin of bird, and body of bird are thus seen to be complex. Marked variations in any one of them or in the relations of any two of them very probably affect the temperature to which the embryo in the egg is subjected. Since the bird embryos cannot regulate their own temperature, the reason for fluctuations is evident. The embryo to survive and develop must endure these fluctuations. It is probable that during the course of evolution the embryo has not only become adjusted to these conditions but has become so adapted that such conditions are its optimum. The behavior of the adult bird is adjusted to maintain these conditions and to keep them as constant as possible. In different species of birds in this same region (northern Ohio) and in other regions, nest conditions and nesting behavior are different. It is important that these species be studied, not only for comparative purposes of physiology, but also to correlate them with the ecological conditions of their environment.

SUMMARY AND CONCLUSIONS

1. The purpose of these researches was to learn the physiology of bird temperature and the relation and dependency of bird temperature on environmental conditions. Experimental studies under controlled conditions were undertaken to analyze the factors affecting avian temperature, and careful studies were then made of the manner in which these same factors affect the bird under natural conditions. This study is, in part, a contribution to our knowledge of the physiological ecology of birds. (Pages 7–9.)

2. Several passeriform species were studied, but most of the work was performed on the eastern house wren, *Troglodytes aedon aedon,* which is ecologically a typical member of preclimax communities in the Acer-Fagus and Quercus-Castanea Associations of the eastern United States and Canada. (Pages 8–10.)

3. Mercury thermometers were at first employed, but soon found inadequate for the type of investigation in view. Use was then made of copper-constantan thermocouples prepared in different ways for various purposes. Temperatures were determined by both indicator and recording potentiometer pyrometers. (Pages 12–21.)

4. To afford a basis for comparing the influence of other factors, the standard temperature was determined, i.e., the body temperature of birds at standard metabolism. For the eastern house wren, this is 104.4° F. (40.2° C.) in the male and 105.0° F. (40.6° C.) in the female. Standard temperatures determined for 4 other species are approximately similar. (Pages 22–31.)

5. Aside from the standard temperature, which is fairly constant during the daytime, the body temperature normal to the eastern house wren and other passeriform species is characterized by great variableness. (Page 31.)

6. Emotional excitement, through its effect on activity and other functions, tends indirectly to increase the body temperature. The most important single factor causing variations in temperature is muscular activity. An increase in activity is followed im-

mediately by a rise in body temperature, while a decrease in activity is followed by a fall. The maintenance of high temperature is dependent on a constant and adequate supply of food. Starvation causes a drop in body temperature below standard level. (Pages 31–42.)

7. Under experimental conditions, the body temperature of adult birds is normally unaffected by fluctuations in air temperature so long as these fluctuations are not extreme and do not occur too rapidly. Birds are more quickly and seriously affected by a rise in body temperature than by a lowering. The lower and upper lethal limits of body temperature for the adult eastern house wren are 71.0° F. (21.9° C.) and 116.3° F. (46.8° C.), respectively. (Pages 42–50.)

8. Variations in the rate of the respiratory movements of adult birds is probably of significance in temperature regulation. The breathing rate is low at standard temperature. In the male eastern house wren, this average is 112 times a minute, and in the female 92. At lower body temperatures, this rate of breathing increases to 240 times a minute at 100° F. (37.8° C.), then decreases as the body temperature falls. At high body temperatures, the rate also increases, in one instance up to 340 times a minute at 116° F. (46.7° C.). After the upper lethal body temperature is reached, the rate of breathing steadily decreases. (Pages 50–55.)

9. The skin temperature of passeriform birds, as illustrated by the eastern house wren, is lower than that of the body, varies in different parts of the body, and is not in all cases the same in the 2 sexes. The skin temperature of the breast and belly averages 1.3° F. (0.7° C.) lower than that inside the body, and is not affected by differences in air temperature. (Pages 56–61.)

10. During the periods of attentiveness, when the adult female is incubating the eggs, her body temperature is high as she first comes on the nest. It then drops as she settles down and becomes quiet, but rises again before she leaves a few minutes later. During the period of inattentiveness, when the female is away procuring food for herself, her temperature, in general, rises. The average initial body temperature, during a period of attentiveness on the nest, in the case of 12 individuals of 8 passeriform species, was ascertained to be 107.6° F. (42.0° C.); the average highest temperature while on the nest is 108.1° F. (42.3° C.); the lowest

is 106.5° F. (41.4° C.); and the last temperature of the bird before she leaves is 107.2° F. (41.8° C.). The temperature of the female while actually incubating the eggs during the day (attentive periods) averages 107.3° F. (41.8° C.), while her temperature during the short periods of absence (inattentive periods) averages 107.4° F. (41.9° C.). (Pages 64–72.)

11. Considering the daylight period as a whole, the body temperature of female birds of 8 passeriform species averages 107.3° F. (41.8° C.) during the incubation period. At night there is a marked drop in average body temperature to 104.6° F. (40.3° C.). Averaging together day and night records for the entire 24-hour day in proper proportions gives 106.3° F. (41.3° C.) as the average body temperature of female birds during the breeding season. No significant difference in body temperature has been noted between the different passeriform species. (Pages 68–72.)

12. There is occasionally a slight positive correlation discernible between fluctuations of bird temperature and of air temperature from day to day, but such correlations are not always present, and may be indirect through the effect of air temperature on activity. (Pages 72–76.)

13. No rise was noted in the temperature of the sitting female during the period of incubation. (Pages 75–76.)

14. There is a decided and rather abrupt daily rhythm of body temperature in passeriform birds. The average body temperature rises gradually during the morning from the beginning of the day's activities (about 4:45 A. M.) until the maximum is reached during the middle of the day. It decreases again during the late afternoon. When the bird settles on the nest for the night (about 7:45 P. M.), the temperature for a short time thereafter (1.25 hours) falls very rapidly (1.8° F. [1.0° C.]). It then decreases gradually until the minimum is reached about midnight. After that, the body temperature fluctuates more or less until 3:30 A. M. There is then a rapid rise (1.7° F. [0.9° C.]) in the body temperature of the female during the short period (1.25 hours) just before leaving the nest for the first time in the morning. There is considerable variation in the time at which both the maximum and minimum body temperatures are reached. This daily rhythm is explained on the basis of the experimental work reported in the

first part of this paper. Variation in muscular activity at different times of the day is the most important single factor involved. Other related influencing factors are air temperature, the digestion and absorption of food, and mental activity and rest. (Pages 76–91.)

15. There is in 8 species of passeriform female birds on the nest during incubation a daily variation between average extremes of body temperature amounting to 5.3° F. (103.4° to 108.7° F.) or 2.9° C. (39.7° C. to 42.6° C.). The lowest apparently normal body temperature that has been obtained in any of these passeriform birds is 102.0° F. (38.9° C.), while the highest is 112.3° F. (44.6° C.). The greatest possible normal fluctuation in passeriform bird temperature, then, is over 10° F. (5.6° C.). (Pages 88–90.)

16. The daily rhythm in body temperature was experimentally controlled and reversed by appropriately regulating the period of the bird's activity. An anaesthetic used on a bird destroyed the daily rhythm entirely, and body temperatures were maintained constant. This again indicates the importance of muscular exertions in the variability of a bird's temperature. (Pages 91–94.)

17. In birds, as in other animals, two factors are concerned in temperature regulation: the mechanism regulating heat production, and the mechanism regulating heat loss. Muscular activity greatly affects heat production and is very important in causing variations in body temperature. High air temperatures depress, while low temperatures stimulate heat production. Starvation decreases, but food stimulates the amount of heat produced, and so these factors are concerned in regulating body temperature. Aside from a probable nervous control over heat production, a hormonal regulation may also be very important. Because of the covering of feathers, only a little heat is lost through the general body surface. Feathers are of great aid, therefore, in protecting the bird in cold weather. The mechanism whereby heat is dissipated is largely centered in the lungs and air-sacs, and is regulated with the respiration. (Pages 94–104.)

18. Young eastern house wrens are distinctly poikilothermic (cold-blooded) in their temperature reactions. The development of temperature control was determined experimentally to follow the sigmoid growth curve. It is relatively complete when the bird becomes 9 days old. Factors involved in the devel-

opment of this temperature control are increase in total heat production, decrease in proportion of body surface to bulk, development of feathers, development of functioning air-sacs, and development of nervous and hormonal control. (Pages 105–113.)

19. Before the development of a temperature control in the young eastern house wren, the rate of respiratory movements varies directly with the temperature. As soon as temperature control is attained, the rate of respiration varies as in the adult. (Pages 114–117.)

20. Lethal results follow quickly when the body temperature of the young eastern house wren is raised to 115.9° F. (46.6° C.) or above. The degree of body temperature that is lethal is approximately the same for all ages. Excessive heat kills young birds more quickly than does cold. (Pages 117–121.)

21. For the nestling eastern house wren, 10 days or older, a drop in body temperature below 60° F. (15.6° C.) proves fatal. For the house wren before the development of temperature control (up to 9 days of age), the low lethal body temperature is approximately 47.0° F. (8.3° C.). This is produced by an air temperature slightly lower. There is thus with age a decrease in the extent to which body temperature can be lowered without harm. (Pages 121–124.)

22. Before the development of a temperature control, the survival time without food of the nestling eastern house wren is longer at low air temperature than at high air temperature. After the attainment of a temperature control, however, survival time at low air temperature is not so long as at high. (Pages 124–127.)

23. The temperature of young birds in the nest before development of a temperature control varies directly with that of the nest, and fluctuates up and down between the times of brooding and inattentiveness by the adult bird. During the period in the nest there is a gradual rise of body temperature independent of environmental conditions and dependent upon the development of the temperature regulating mechanism. This rise amounts to 0.6° F. (0.3° C.) per day. (Pages 127–132.)

24. Egg temperature under experimental control varies directly and rapidly with air temperature. The temperature of the egg in relation to air temperature increases during the incubation period, due probably to heat generated by the developing embryo. Some

evidence is presented that the eastern house wren's embryos can withstand extreme temperatures from freezing up to 114° F. (45.6° C.). When subjected to low temperatures (60°–70° F. [15.6°–21.1° C.]), embryos at all stages will survive an exposure of as much as 16 hours (in one case 24 hours, in another 30 hours). During the first 8 days of incubation, a delay in hatching of about 6.9 hours was produced by exposure to low air temperatures; but during the latter days of incubation, no delay was produced. (Pages 134–144.)

25. Comparing the resistance of eggs, young birds, and adults to high body temperature, only slight, probably insignificant, differences were found to occur. However, a progressive decrease in endurance to low body temperature occurs with increase of age. (Pages 141, 142.)

26. The temperature of the eastern house wren's egg in the nest was found to fluctuate between the average limits of 98.5° F. (37.0° C.) and 93.1° F. (34.0° C.), the higher temperature occurring when the adult is incubating. The optimum incubation temperature for the eastern house wren is 100° F. (37.8° C.) or below, rather than above. The suggestion is made that probably fluctuating temperature is more favorable for incubation in this species than is constant temperature. (Pages 145–151.)

27. Fluctuations of temperature in the nest were determined to be greatest at the level of the upper surface of the eggs and least at the bottom and back. Gradients extend downward and around the eggs when the adult is incubating and in reverse direction when the adult is absent. (Pages 151–154.)

BIBLIOGRAPHY

In this bibliography there are included only those references that are referred to in the text. It comprises, however, all the important papers having a more direct bearing upon the physiology of temperature in birds. Numerous minor papers dealing with the temperature of birds taken under unnatural or uncontrolled conditions by thermometers are not here included.

Allen, Glover Morrill.

1925. Birds and Their Attributes, pp. I–XIII, 1–338, pls. I–XLV.

Ansiaux, George.

1890. La Mort par le Refroidissement. Contribution à l' tude de la Respiration et de la Circulation. Archives de Biologie, Tome X, 1890, pp. 151–186.

Atwood, Horace.

1917. The Incubation of Hen Eggs. Circular No. 25, Agricultural Experiment Station, West Virginia University, 1917, pp. 1–24.

Babák, Edward.

1902. Ueber die Wärmeregulation bei Neugeborenen. [Pflüger's] Archiv für die gesammte Physiologie des Menschen und der Thiere, Band LXXXIX, Heft 3–4, Januar 31, 1902, S. 154–177.

Baerensprung, Felix von.

1851. Untersuchungen über die Temperaturverhältnisse des Foetus und des erwachsenen Menschen im gesunden und kranken Zustande. Archiv für Anatomie, Physiologie, und wissenschaftliche Medicin, 1851, S. 126–175.

Baldwin, Samuel Prentiss.

1919. **Bird Banding by Means of Systematic Trapping.** Abstract of the Proceedings of the Linnaean Society of New York, No. 31, for 1918–1919 (December 23, 1919), pp. 23–56, pls. I–VII.

Baldwin, Samuel Prentiss; and Kendeigh, Samuel Charles.

1927. **Attentiveness and Inattentiveness in the Nesting Behavior of the House Wren.** The Auk, Vol. XLIV, No. 2, April, 1927, pp. 206–216, pls. X–XIII.

Barbour, Henry Gray.

1921. **The Heat Regulating Mechanism of the Body.** Physiological Reviews, Vol. I, No. 2, April, 1921, pp. 295–326.

Bazett, Henry Cuthbert.

1927. **Physiological Responses to Heat.** Physiological Reviews, Vol. VII, No. 4, October, 1927, pp. 531–599.

Becquerel, L. Alfred; and Breschet, Gilbert.

1838. **Nouvelles Observations sur la Mésure de la Température des Tissues Organiques du Corps de l'Homme et des Animaux au Moyen des Effets Thermo-electriques.** Annales des Sciences Naturelles, 2de Série, Tome IX, Mai, 1838, pp. 271–280.

Benedict, Francis Gano; and Carpenter, Thorne Martin.

1918. **Food Ingestion and Energy Transformations with Special Reference to the Stimulating Effect of Nutrients.** Publication 261, Carnegie Institution, Washington, 1918, pp. 1–355.

Benedict, Francis Gano; and Fox, Edward L.

1927. **The Gaseous Metabolism of Large Wild Birds under Aviary Life.** Proceedings of the American Philosophical Society, Vol. LXVI [Bicentenary Number], 1927, pp. 511–534.

Benedict, Francis Gano; Miles, Walter Richard; and Johnson, Alice.

1919. The Temperature of the Human Skin. Proceedings of the National Academy of Sciences, Vol. V, 1919, pp. 218–222.

Benedict, Francis Gano; and Riddle, Oscar.

1929. The Measurement of the Basal Heat Production of Pigeons. Journal of Nutrition, Vol. I, No. 6, 1929, pp. 475–536.

Benedict, Francis Gano; and Snell, John Ferguson.

1902. Körpertemperatur-Schwankungen mit besonderer Rücksicht auf den Einfluss, welchen die Umkehrung der täglichen Lebensgewohnheit beim Menschen ausübt. [Pflüger's] Archiv für die gesammte Physiologie des Menschen und der Thiere, Band XC, 1902, S. 33–72.

Benedict, Francis Gano; and Talbot, Fritz Bradley.

1915. The Physiology of the New-born Infant; Character and Amount of the Katabolism. Publication 233, Carnegie Institution, Washington, 1915, pp. 1–126.

Bergtold, William Henry.

1917. A Study of the Incubation Periods of Birds, pp. 1–109.

1926. Avian Thyroids. The Auk, Vol. XLIII, No. 4, October, 1926, pp. 557–558.

Boulton, Rudyerd.

1927. Ptilosis of the House Wren (Troglodytes aedon aedon). The Auk, Vol. XLIV, No. 3, July, 1927, pp. 387–414.

Britton, Sidney William.

1922. Effects of Lowering the Temperature of Homoiothermic Animals. Quarterly Journal of Experimental Physiology, Vol. XIII, 1922, pp. 55–68.

Cannon, Walter Bradford; Querido, A.; Britton, Sidney William; and Bright, E. M.

1927. **Studies on the Conditions of Activity in Endocrine Glands, XXI—The Role of Adrenal Secretion in the Chemical Control of Body Temperature.** American Journal of Physiology, Vol. LXXIX, No. 2, 1926–1927, pp. 466–507.

Cartwright, Bertram William; and Harrold, Cyril Guy.

1925. **An outline of the Principles of the Natural Selective Absorption of Radiant Energy.** The Auk, Vol. XLII, No. 2, April, 1925, pp. 233–241.

Cassidy, G. T.; Dworkin, Samuel; and Finney, William Harper.

1926. **The Action of Insulin on the Domestic Fowl.** American Journal of Physiology, Vol. LXXV, 1926, pp. 609–615.

Chossat, Charles.

1843. **Recherches Expérimentales sur l'Inanition.** Annales des Sciences Naturelles, Zoologie, 2de Série, Tome XX, 1843, pp. 54–81, 182–214, 293–326.

Corin, Gabriel; and Beneden, A. van.

1887. **Recherches sur la Régulation de la Température chez les Pigeons privés d'Hémisphère Cérébraux.** Archives de Biologie, Tome VII, 1887, pp. 265–276.

Cramer, William.

1916. **On the Thyroid-adrenal Apparatus and its Functions in the Heat Regulation of the Body.** The Journal of Physiology, Vol. L, 1915–1916, Proceedings, pp. XXXVIII-XXXIX.

1918. **Further Observations on the Thyroid-adrenal Apparatus.** A Histochemical Method for the Demonstration of Adrenaline Granules in the Suprarenal Gland. The Journal of Physiology, Vol. LII, 1918, p. 13.

Cramer, William; and Ludford, R. S.

1926. On Cellular Activity and Cellular Structure as Studied in the Thyroid Gland. The Journal of Physiology, Vol. LXI, 1926, pp. 398–408.

Cramer, William; and McCall, R.

1916. On Carbohydrate Metabolism in Experimental Hyperthyroidism. The Journal of Physiology, Vol. L, 1915–1916, Proceedings, pp. XXXVI–XXXVIII.

Dougherty, John Edwin.

1926. Studies in Incubation, I—The Effect of Low Temperatures Previous to Incubation on Hatchability of Eggs Set. American Journal of Physiology, Vol. LXXIX, 1926, pp. 39–43.

Downing, A. C.; Gerard, R. W.; and Hill, Archibald Vivian.

1926. The Heat Production of Nerve. Proceedings of the Royal Society, London, Series B, Vol. C, 1926, pp. 223–251.

Edwards, Charles Lincoln.

1902. The Physiological Zero and the Index of Development for the Eggs of the Domestic Fowl, Gallus domesticus. American Journal of Physiology, Vol. VI, No. 6, 1902, pp. 351–397.

Edwards, William Frederic.

1839. Animal Heat. Todd's Cyclopedia of Anatomy and Physiology, Vol. II, 1839, pp. 648–684.

Eycleshymer, Albert Chauncey.

1907. Some Observations and Experiments on the Natural and Artificial Incubation of the Egg of the Common Fowl. Biological Bulletin, Vol. XII, No. 6, 1907, pp. 360–375.

Féré, Charles.

1899. La Température de la Poule. Journal de l'Anatomie et de la Physiologie Normales et Pathologiques de l'Homme et des Animaux, Tome XXXV, pp. 808–816.

Gamgee, Arthur.

1908. On Methods for the Continuous (Photographic) and Quasicontinuous Registration of the Diurnal Curve of Temperature of the Animal Body. Philosophical Transactions of the Royal Society, London, Series B, Vol. CC, 1908, pp. 219–240, pl. XX.

Gardner, Leon Lloyd.

1930. On the Body Temperature of Nestling Altricial Birds. The Auk, Vol. XLVII, No. 3, July, 1930, pp. 367–379.

Gavarret, Jules.

1855. De la Chaleur Produite par les Êtres Vivants, pp. I–IV, 1–560.

Gesell, Robert.

1925. The Chemical Regulation of Respiration. Physiological Reviews, Vol. V, No. 4, October, 1925, pp. 551–595.

Groebbels, Franz.

1920. Experimentelle Untersuchungen über den Gasstoffwechsel der Vögel. Zeitschrift für Biologie, Band LXX, 1920, S. 477–504.

1928. (a) Fortgesetzte Untersuchungen über den Stoffwechsel der Vögel und das Stoffwechselproblem im allgemeinen. Zeitschrift für Biologie, Band CCXVIII, 1928, S. 98–114.

(b) Zur Physiologie des Vogelzuges. Verhandlungen der Ornithologischen Gesellschaft in Bayern, Band XVIII, Heft 1–2, Dezember 21, 1928, S. 44–74.

1931. Weitere Untersuchungen über die Körpertemperatur der Zugvögel am Leuchtturm. Der Vogelzug, Jahrgang II, Nr. 2, 1931, S. 167–169.

Gross, Alfred Otto.

1930. Progress Report of the Wisconsin Prairie Chicken Investigation, pp. 1–112.

Hadwen, Seymour.

1926. Color in Relation to Health in Wild and Domestic Animals, with a note by E. L. Harrington. Journal of Heredity, Vol. XVII, No. 12, 1926, pp. 450–461.

Hári, Paul.

1917. Beiträge zum Stoff und Energieumsatz der Vögel. Biochemische Zeitschrift, Band LXXVIII, 1917, S. 313–348.

Heilmann, Gerhard.

1926. The Origin of Birds, pp. [i–vi], 1–208, pls. [I], figs. 1–142.

Hildén, Armas; and Stenbäck, K. S.

1916. Zur Kenntniss der Tagesschwankungen der Körpertemperatur bei den Vögeln. Skandinavisches Archiv für Physiologie, Band XXXIV, 1916, S. 382-413

Hill, Leonard Erskine.

1906. Recent Advances in Physiology and Bio-chemistry, pp. I–XIV, 1–751.

Howell, William Henry.

1928. A Text-book of Physiology, pp. 1–1081.

Kallir, Eva.

1930. Temperaturtopographie einiger Vögel; Experimentelle Untersuchungen. Zeitschrift für vergleichende Physiologie, Band XIII, Heft 2, 1930–1931, S. 231–248.

Karrer, Sebastian; and Estabrook, G. B.

1930. Thermocouple for Measuring Internal Body Temperature of Animals. The Journal of the Maryland Academy of Sciences, Vol. I, 1930, pp. 129–147.

Kelso, Leon.

1931. Some Notes on Young Desert Horned Larks. The Condor, Vol. XXXIII, No. 2, March 18, 1931, pp. 60–65.

Kendeigh, Samuel Charles.

The Role of the Environment in the Life of Birds. (In manuscript.)

Kendeigh, Samuel Charles; and Baldwin, Samuel Prentiss.

1928. Development of Temperature Control in Nestling House Wrens. The American Naturalist, Vol. LXII, No. 680, May–June, 1928, pp. 249–278.

Kimball, Arthur Lalanne.

1917. College Physics, pp. I–XII, 1–694.

Kimber, Diana Clifford; and Gray, Carolyn Elizabeth.

1923. Textbook of Anatomy and Physiology, pp. I–VIII, 1–642.

Krogh, August.

1916. The Respiratory Exchange of Animals and Man, pp. 1–173.

Lamson, George Henry, Jr.; and Kirkpatrick, William F.

1918. Factors in Incubation. Bulletin Storrs [Connecticut] Agricultural Experiment Station, No. 95, 1918, pp. 307–351.

Leichtentritt, Bruno.

1919. Die Wärmeregulation neugeborener Säugetiere und Vögel. Zeitschrift für Biologie, Band LXIX, 1919, S. 545–563.

Lillie, Frank Rattray.

1919. The Development of the Chick, pp. I–XI, 1–472.

Lippincott, William Adams.

1921. Poultry Production, pp. I–VIII, 17–541.

Lipschutz, Alexandre; and Illanes, Armando.

1929. Comportement de l'Oeuf de Poule à des Temperatures basses. Comptes Rendus Hebdomadaires des Séances et Mémoires de la Société de Biologie et de ses Filiales, Tome CII, No. 31, Novembre 22, 1929, pp. 555–556.

Locy, William Albert; and Larsell, Olaf.

1916. The Embryology of the Bird's Lung. American Journal of Anatomy, Vol. XIX, 1916, pp. 447–504.

Lusk, Graham.

1928. The Elements of the Science of Nutrition, pp. 1–844.

Marine, David.

1922. The Present Status of the Functions of the Thyroid Gland. Physiological Reviews, Vol. II, 1922, pp. 521–551.

Martins, Charles Frederic.

1858. Mémoire sur la Température des Oiseaux Palmipèdes du Nord de l'Europe. Journal de la Physiologie de l'Homme et des Animaux, Tome I, 1858, pp. 10–41.

Mills, Clarence Alonzo.

1918. Effects of External Temperature on Thyroid Activity. American Journal of Physiology, Vol. XLV, 1917–1918, pp. 557–558.

Mitchell, Harold Hanson; Card, Leslie Ellsworth; and Haines, W. T.

1927. The Effect of Age, Sex, and Castration on the Basal Heat Production of Chickens. Journal of Agricultural Research, Vol. XXXIV, No. 10, 1927, pp. 945–960.

Moran, T.

1925. The Effect of Low Temperature on Hens' Eggs. Proceedings of the Royal Society, London, Series B, Vol. XCVIII, 1925, pp. 436–456.

Müller, Bruno.

1908. The Air-sacs of the Pigeon. Smithsonian Miscellaneous Collections, Vol. L, 1908, pp. 365–414.

Murray, John.

1826. On the Temperature of the Egg of the Hen, in Relation to its Physiology. Edinburgh Philosophical Journal, Vol. XIV, 1826, pp. 61–63.

Pembrey, Marcus Seymour.

1898. Animal Heat. Schafer's Textbook of Physiology, 1898, pp. 785–867.

Pembrey, Marcus Seymour; Gordon, Mervyn Henry; and Warren, Richard.

1894. On the Response of the Chick, before and after Hatching, to Changes of External Temperature. The Journal of Physiology, Vol. XVII, 1894-95, No. 5, December 15, 1894, pp. 331-348.

Pincus, Gregory.

1931. On the Temperature Characteristics for Frequency of Breathing Movements in Inbred Strains of Mice and in Their Hybrid Offspring. Journal of General Physiology, Vol. XIV, No. 4, March, 1931, pp. 421–443.

Pütter, August von.

1911. Vergleichende Physiologie, : S. I–VIII, 1–721.

Raudnitz, Robert W.

1888. Die Wärmeregelung beim Neugeborenen. Zeitschrift für Biologie, Band XXIV, 1888, S. 423–552.

Riddle, Oscar.

1908. The Genesis of Fault-bars in Feathers and the Cause of Alteration of Light and Dark Fundamental Bars. Biological Bulletin, Vol. XIV, 1908, pp. 352–354.

1927. Metabolic Changes in the Body of Female Pigeons at Ovulation. Proceedings of the American Philosophical Society, Vol. LXVI [Bicentenary Number], 1927, pp. 497–509.

1928. Sex and Seasonal Differences in Weight of Liver and Spleen. Proceedings of the Society of Experimental Biology and Medicine, Vol. XXV, 1928, pp. 474–476.

Riddle, Oscar; Christman, G.; and Benedict, Francis Gano.

1930. Differential Response of Male and Female Ring Doves to Metabolism Measurement at Higher and Lower Temperatures. American Journal of Physiology, Vol. XCV, No. 1, 1930, pp. 111–120.

Riddle, Oscar; and Fisher, W. S.

1925. Seasonal Variation of the Thyroid Size in Pigeons. American Journal of Physiology, Vol. LXXII, 1925, pp. 464–487.

Riddle, Oscar; Nussmann, Theodora Clara; and Benedict, Francis Gano.

1932. Metabolism During Growth in a Common Pigeon. American Journal of Physiology, Vol. CI, No. 2, July, 1932, pp. 251–259.

Riddle, Oscar; Smith, Guinevere C.; and Benedict, Francis Gano.

1932. The Basal Metabolism of the Mourning Dove and Some of its Hybrids. American Journal of Physiology, Vol. CI, No. 2, July, 1932, pp. 260–267.

Simpson, Sutherland.

1911. Observations on the Body Temperature of the Domestic Fowl (Gallus gallus) during Incubation. Transactions of the Royal Society of Edinburgh, Vol. XLVII, Part III, No. 21, 1911, pp. 605–617.

1912. (a) Observations on the Body Temperature of Some Diving and Swimming Birds. Proceedings of the Royal Society of Edinburgh, Vol. XXXII, ([for] 1911–12), Part 1, No. 5, February 16, 1912, pp. 19–35.

(b) An Investigation into the Effects of Seasonal Changes on Body Temperature. Proceedings of the

Royal Society of Edinburgh, Vol. XXXII, [for] 1911–1912), Parts I–II, April–May, 1912, pp. 110–135.

Simpson, Sutherland; and Galbraith, J. J.

1905. An Investigation into the Diurnal Variation of the Body Temperature of Nocturnal and Other Birds, and a Few Mammals. The Journal of Physiology, Vol. XXXIII, 1905, pp. 225–238.

Starling, Ernest Henry.

1930. Principles of Human Physiology, Fifth Edition, pp. I–XV, 1–1039.

Stier, T. J. B.; and Pincus, Gregory.

1928. Temperature Characteristics for Frequency of Respiratory Movements in Young Mammals. Journal of General Physiology, Vol. XI, No. 4, 1928, pp. 349–356.

Stoner, Dayton.

1926. Temperature Studies on the Bank Swallow. [Abstract.] Anatomical Records, Vol. XXXIV, No. 3, 1926, p. 132.

1928. The Increase in Temperature and Weight of Young House Wrens. Proceedings of the Iowa Academy of Science, Vol. XXXV, 1930, pp. 337–339.

Sumner, Francis Bertody.

1913. The Effects of Atmospheric Temperature Upon the Body Temperature of Mice. Journal of Experimental Zoology, Vol. XV, No. 3, 1913, pp. 315–378.

Sutherland, Alexander.

1899. On the Temperature of the Ratite Birds. Proceedings of the Zoological Society of London, 1899, pp. 787–790.

Victorow, Constantin.

1909. Die kühlende Wirkung der Luftsäcke bei Vögeln. [Pflüger's] Archiv für die gesammte Physiologie des

Menschen und der Thiere, Band CXXVI, Heft 5–8, Januar 19, 1909, S. 300–322.

Wetmore, Alexander.

1921. A Study of the Body Temperatures of Birds. Smithsonian Miscellaneous Collections, Vol. LXXII, No. 12, 1921, pp. 1–52.

INDEX TO VOLUME III

Owing to the nature of the matter in this volume, some of the wording in this index is paraphrased from the actual wording in the text. Page references to authors on the pages of the bibliography are preceded by the abbreviation (bibliog.).

Acer-Fagus association, 9, 155
Acknowledgments, 6
Activity, effect of muscular, 19, 22, 29, 31, 32, 33, 34–37, 38, 40, 41, 42, 44, 54, 59, 66, 67, 69, 74, 75, 76, 77, 80, 81, 90, 91, 94, 95, 107, 155, 156
Adrenal glands, 97, 102
aedon, Troglodytes aedon, 8, 9, 10, 155, 163
aedon aedon, Troglodytes, 8, 9, 10, 155, 163
aestiva, Dendroica aestiva, 10
aestiva aestiva, Dendroica, 10
Age, effect of, 107, 120, 123, 124, 142, 159, 160, 169
Age on resistance to low temperatures, effect of, 142
Air humidity, 43, 44, 143, 149, 150
  temperature ,19, 20, 21, 29, 30, 38, 40, 41, 42–45, 47, 49, 56, 59, 60, 61, 64, 72, 74, 75, 78, 90, 91, 93, 94, 96, 97, 98, 99, 105, 106, 107, 112, 113, 116, 117–124, 126, 127, 130, 132, 133, 136, 137, 138, 139–144, 147, 151, 152, 154, 158, 172.
  temperature, daily fluctuation in, 74, 89, 90, 93
  temperature, daily maximum, 80, 87, 90, 132
  temperature, daily minimum, 43, 81, 89, 90, 132
  temperature, daily rhythm in, 79, 93, 132
  temperature, effect of fluctuations in, 42–45, 61, 64, 117, 119, 120, 132
  temperature, effect of high, 87, 96, 113, 117–121, 139–141, 158
  temperature, effect of low, 75, 96, 99, 119, 121–124, 141–144, 158, 159, 160, 163, 171
  temperature, fluctuation in, 20, 21, 42–45, 61, 64, 74, 89, 90, 91, 93, 122, 123, 124, 130, 132, 135, 136, 147, 156, 157, 170
  temperature, lethal, 117–119
  temperature, resistance of young birds to high, 113
  temperature, resistance of young birds to low, 113
  temperature, survival at high, 124–127, 159
  temperature, survival at low, 159
  temperature on eggs, effect of fluctuation of, 134, 135
  temperatures, difference between egg and, 133, 136
  temperatures, high, 76, 140, 171
  thermograph, 78
Air-sacs, 100, 101, 102, 103, 104, 111, 113, 117, 170, 172
  development of, 110
Allen, Glover Morrill, 99, (bibliog.) 161
Altricial bird, 106, 111, 139
  bird, body temperature of young, 166
  nestling bird, 111
Anaesthetics, effect of, 93, 94, 103, 158
Animals, cold-blooded, 7, 47, 50, 105, 106, 142, 143
  domestic, 167
  poikilothermic (cold-blooded) stage in development of warm-blooded, 105–107
  warm-blooded, 5, 7, 47, 50, 94, 95, 105, 107, 143, 163
Ansiaux, George, 50, (bibliog.) 161
Apteryx, 22
Archilochus colubris, 9
Association, Acer-Fagus, 9, 155
  hard maple-beech, 9
  magnolia-bay forest, 9
  Magnolia-Tamala, 9
  oak-chestnut, 9
  Quercus-Castanea, 9
  southern pine forest, 9
Associes, Pinus, 9
ater, Molothrus ater, 10
ater ater, Molothrus, 10

Attentive period, 18, 19, 56, 64, 65, 66, 67, 68, 69, 70, 74, 75, 78, 127, 128, 129, 130, 146, 147, 148, 153, 156, 157
period, highest temperature of, 68, 70, 71, 78, 156
period, initial temperature of, 67, 68, 70, 78, 156
period, last temperature of, 67, 68, 70, 78, 157
period, lowest temperature of, 68, 70, 78, 156–157
period, median temperature of, 68, 70, 71, 78, 157
Attentiveness, 64, 66, 67, 68, 70, 153, 162
effect of, 18, 19, 131, 132, 156, 158, 159
period of, see attentive period
Attentiveness of adult bird, effect of, 131, 132.
Atwood, Horace, 142, (bibliog.) 161
auratus luteus, Colaptes, 10
Average differences in skin temperatures between sexes of the eastern house wren, 58
Average temperature of female birds on nest during incubation, 64–72

Babák, Edward, 105, (bibliog.) 161
Baerensprung, Felix von, 133, (bibliog.) 161
Baldwin, Samuel Prentiss, 12, (bibliog.) 162
Baldwin, Samuel Prentiss, and Kendeigh, Samuel Charles, 6, 13, 15, 22, 64, 103, 106, 107, 108, 110, 113, 121, 128, (bibliog.) 162, (bibliog.) 168
Samuel Prentiss, and Kendeigh, Samuel Charles, Physiology of the Temperature of Birds, 1–173
Baldwin Bird Research Laboratory, 6
Banding of birds, 12
Bank swallow, 172
Barbour, Henry Gray, 5, 94, (bibliog.) 162
Basal metabolism, 22, 23, 171
Basic temperature control, 112
Bazett, Henry Cuthbert, 5, 94, (bibliog.) 162
Becquerel, L. Alfred, and Breschet, Gilbert, 15, (bibliog.) 162
Behavior, bird, 6, 8, 40
nesting, 11, 63–64, 67, 80, 130, 148, 154, 162
physiological, 31
Behavior of adult eastern house wren, 145
of bird on nest, 63
of birds during the experiments, 25–26
of house wren, nesting, 162
Belly temperature, 12, 57, 58, 60, 61, 63
Beneden, A. van; Corin, Gabriel, and, 77, (bibliog.) 164
Benedict, Francis Gano, and Carpenter, Thorne Martin, 37, (bibliog.) 162
Francis Gano, and Fox, Edward L., 28, (bibliog.) 162
Francis Gano; Miles, Walter Richard; and Johnson, Alice, 59, (bibliog.) 163
Francis Gano, and Riddle, Oscar, 38, 40, 69, 90, 96, (bibliog.) 163
Francis Gano; Riddle, Oscar; Christman, G., and, 28, (bibliog.) 171
Francis Gano; Riddle, Oscar; Nussmann, Theodora Clara, and, 111, (bibliog.) 171
Francis Gano; Riddle, Oscar; Smith, Guinevere C., and, 28, (bibliog.) 171
Francis Gano, and Snell, J. F., 37, (bibliog.) 163
Francis Gano, and Talbot, Fritz Bradley, 105, (bibliog.) 163
Bergtold, William Henry, 5, 97, 133, 149, (bibliog.) 163
Bibliography, 161–173
Biological Survey, 12
Bird, altricial, 106, 111, 139
altricial nestling, 111
body temperature of incubating, 64–72, 148, 149, 154, 156, 157
body temperature of young altricial, 166
cold-blooded, 106
domesticated, 148
effect of brooding of parent, 151, 152
effect of handling of, 24, 25, 107
effect of thrusting cold thermometer into young, 13
fluctuation in body temperature of passeriform, 155
fluctuation in body temperature of young, 132
migrating, 78
Bird, minimum body temperature of young, 132
nocturnal, 77
non-passeriform, 32

passeriform, 22, 26, 33, 41, 42, 50, 61, 63, 64, 69, 70, 72, 75, 78, 155, 157, 158
specific gravity of, 104
young altricial, 111
Bird at night, body temperature of, 76, 77, 80, 147
behavior 6, 8, 40
on nest, effect of position of, 152
on nest, method of obtaining temperature of, 62
on nest, temperature of, 89
on temperature of nest, effect of absence of, 151, 152
Research Laboratory, Baldwin, 11, 12
respiration, 103
temperature, daily fluctuation in, 74, 88, 89, 172
temperature, fluctuation in, 13, 88
temperature, greatest normal fluctuation in passeriform bird, 158
temperature, lethal, 117–119
temperature maximum daily, 77, 79, 88, 89, 90
temperature, median daily, 69, 71, 78, 157
temperature, minimum daily, 77, 81, 88, 89, 90
Birds, banding of, 12
body temperature of, 22–132, 155, 172
body temperature of nestling, 105–132, 138
body temperature of adult, 13, 22–104, 131
cold-blooded stage in young, 125
daily rhythm in body temperature of young, 132
daily rhythm in body temperature of passeriform, 157
development of temperature control in young, 108–113
distribution of, 6
diurnal, 77, 91
fluctuation in body temperature of, 7, 13, 22, 29, 34, 35, 38, 42, 43, 63, 72–76, 88, 90, 116, 155, 157
highest rate of respiration in young, 115
insectivorous, 38
low lethal body temperature of young, 124
maximum body temperature of, 33, 34, 46, 47, 69, 87, 88, 89, 90, 91, 109, 117, 119, 157
metabolism of, 5, 6
minimum body temperature of, 50, 69, 78, 81, 87, 88, 89, 90, 91, 119, 157
nesting behavior of, 148
rate of respiratory movements in young, 114–117
respiration in, 110
sea, 22
skin temperature of passeriform, 156
standard temperatures of young, 112
temperature of, I–X, 1–173
upper lethal temperature of young, 119
young, 11, 106
Birds at high and low temperatures, survival time of young, 124-127
at night, temperature fluctuation of young, 131
before determining standard temperature, treatment of, 23–25
during experiments, behavior of, 25–26
immediately after killing, temperature of, 22, 31
in the nest, normal temperature of young, 127–132
included in this study, scientific names of, 9–10
on nest during incubation, average temperature of female, 64–72
other than house wren, maximum body temperature of, 33
to high temperature, resistance of young, 113, 117–121
to low body temperature, resistance of young, 143, 144
to low temperature, resistance of young, 121–124
Blackbird, young, 106
Blood, development of circulation of, 111
Bluebird, eastern, 10, 13, 33
Bob-white, eastern, 9, 13, 49
Body, effect of size of, 100, 109, 120, 124
Body heat, 8
metabolism, 105
temperature, 5, 7, 13, 14, 16, 22–132, 138, 139, 146, 158, 159, 160, 166, 167, 171, 172
temperature, chemical control of, 96
temperature, daily rhythm in, 69, 76–91, 94, 132, 157, 158
temperature, effect of age in, 107
temperature, effect of continuous low, 126

temperature, high, 44, 45, 47, 51, 76, 77, 139
temperature, highest, see maximum
temperature, internal, 15, 16, 57, 58, 59, 168
temperature, lethal, 45–50, 120
temperature, low, 40, 41, 42, 51, 54, 76, 77, 123, 139, 156
temperature, lower lethal, 47–50, 123, 142, 144, 156, 159
temperature, lower limit of, 44, 45, 50, 156
temperature, normal, 123
temperature, normal high, 126
temperature, resistance of young birds to high, 121, 139
temperature, resistance of young birds to low, 121–124, 139, 143, 144
temperature, seasonal fluctuation of, 76, 97
temperature, upper lethal, 44, 45–47, 52, 54, 123, 141, 156
temperature, upper limit of, 44, 47
temperature at night, lowest, 80
temperature from day to day, fluctuation in, 72–76
temperature in man, maximum, 80
temperature in man, minimum, 80
temperature of adult birds, 13, 22–104, 131
temperature of adult birds taken with mercury thermometer, 13
temperature of animal, 166
temperature of bird at night, 76, 77, 80, 147
temperature of birds, 13, 14, 22–132, 155, 172
temperature of birds, fluctuations in, 7, 13, 22, 29, 34, 35, 38, 42, 43, 63, 72–76, 88, 90, 116, 155, 157
temperature of birds, lowest, see minimum
temperature of birds, maximum, 33, 34, 46, 47, 69, 87, 88, 89, 90, 91, 109, 117, 119, 157
temperature of birds, minimum, 50, 69, 78, 81, 87, 88, 89, 90, 91, 119, 157
temperature of birds other than house wren, maximum, 33
temperature of birds under natural conditions, 61–64
temperature of birds when held in hand after capture, fall in, 35–36
temperature of eastern house wren, maximum, 32
temperature of house wren, upper lethal, 141
temperature of incubating bird, 64–72, 148, 149, 154, 156, 157
temperature of man, 162, 163
temperature of man, internal, 15
temperature of nestling altricial bird, 166
temperature of nestling birds, 105–132, 138
temperature of passeriform bird, fluctuation in, 155
temperature of passeriform birds, daily rhythm in, 157
temperature of various passeriform birds (females) on the nest during period of incubation, 70–71
temperature of young altricial bird, 166
temperature of young bird, low lethal, 124
temperature of young bird, maximum, 132
temperature of young bird, minimum, 132
temperature of young birds, daily rhythm in, 132
temperatures, rate of respiratory movements at different, 50–55
temperatures, relation between skin and, 131
Boerhaave, 12
Bombycilla cedrorum, 10
boreus, Myiarchus crinitus, 10
Boulton, Rudyerd, 6, 110, (bibliog.) 163
Bowen, Wilfrid Wedgwood, 6
brachidactyla, Geothlypis trichas, 10
brachyrhynchos, Corvus brachyrhynchos, 10
brachyrhynchos brachyrhynchos, Corvus, 10
Breast temperature, 57, 58, 60, 61, 63
Breschet, Gilbert; Becquerel, L. Alfred; and, 15, (bibliog.) 162
Bright, E. M.; Cannon, Walter Bradford; Querido, A.; Britton, Sidney William, and, 97, (bibliog.) 164
Brooding of parent bird, effect of, 151, 152
Brown thrasher, 10, 49
Brush Laboratories, 6

Cannon, Walter Bradford; Querido, A.; Britton, Sidney William, and Bright, E. M., 97, (bibliog.) 164
Carbohydrate, 37, 38, 95

Carbohydrate metabolism, 38, 165
Card, Leslie Ellsworth; and Haines, W. T.; Mitchell, Harold Hanson, 111, 112, (bibliog.) 169
Cardinal, eastern, 10, 49
cardinalis, Richmondena cardinalis, 10
cardinalis cardinalis, Richmondena, 10
carolinensis, Dumetella, 10
Sitta carolinensis, 10
Zenaidura macroura, 9
carolinensis carolinensis, Sitta
carolinus, Centurus, 10
Carpenter, Thorne Martin; Benedict, Francis Gano, and, 37, (bibliog.) 162
Cartwright, Bertram William, and Harrold, Cyril Guy, 100, (bibliog.) 164
Cassidy, G. T.; Dworkin, Samuel; and Finney, William Harper, 97, (bibliog.) 164
Cat, 50
Catbird, 10, 13, 49, 66, 70, 71, 72, 74, 88, 89, 90, 149
Cedar waxwing, 10, 66, 70, 71, 88, 89, 149
cedrorum, Bombycilla, 10
Centigrade scale, 18
Centurus carolinus, 10
Chemical control of body temperature, 96
reactions, van't Hoff's law for, 125–126
Chick, 77, 106, 168
Chicken, 101, 103, 107, 170
prairie, 124, 167
young, 106
young domestic, 111
young prairie, 124
Chipping sparrow, eastern, 10, 25, 27, 28, 29, 30, 33, 35, 36, 38, 41, 49, 53, 55, 66, 70, 71, 88, 89, 91, 92
Chossat, Charles, 40, 41, 76, (bibliog.) 164
Christman, G.; and Benedict, Francis Gano; Riddle, Oscar, 28, 96, (bibliog.) 171
Circulation [of blood], 50, 57, 60, 61, 64, 162
of blood, development of, 111
Clinical thermometer, 12, 36
Colaptes auratus luteus, 10
Cold-blooded animals, 7, 47, 50, 105–107, 142, 143
bird, 106
stage in development of warm-blooded animals, poikilothermic, 105–107, 158
stage in young birds, 125
temperature of young bird, 158
Cole, Leon J., 6
Colinus virginianus virginianus, 9
colubris, Archilochus, 9
Common pigeon, 38, 111
Conclusions, summary and, 155
Constancy of standard temperature, 29–31
Constantan, 15, 16, 18
Control, basic temperature, 112
development of endocrine, 111
development of nervous, 110, 111
Control, development of temperature, 6, 56, 106, 107, 108–113, 125, 130, 159, 168
mechanism of temperature, 28, 40, 41, 42, 43, 47, 49, 51, 54, 56, 94–104, 113, 117, 123, 124, 143, 158, 162
temperature, 33, 59, 94–104, 106, 108–113, 114, 116, 117, 120, 156, 161, 164, 168
Control and reversal of daily temperature rhythm, experimental, 91–94
in the young, temperature, 170
in young birds, development of temperature, 103, 108–113, 168
mechanism, development of temperature, 123, 124, 143
mechanism in man, heat, 105, 106
of body temperature, chemical, 96
of heat loss, 97, 111
of young, basic temperature, 112
Copper, 15, 16, 18
Copper and steel thermocouple, 15
Copper-constantan thermocouple, 15, 56, 155
Corin, Gabriel, and Beneden, A. van, 77, (bibliog.) 164
Corvus brachyrhynchos brachyrhynchos, 10
Cowbird, eastern, 10, 49
Cramer, William, 97, (bibliog.) 164
William, and Ludford, R. S., 97, (bibliog.) 165
William, and McCall, R., 97, (bibliog.) 165
Crested flycatcher, 33
flycatcher, northern, 10, 13, 33, 149
crinitus boreus, Myiarchus, 10
Crow, 97
eastern, 10, 13, 35, 36

Daily bird temperature, maximum, 77, 79, 88, 89, 90
bird temperature, median, 69, 71, 78, 157
bird temperature, minimum, 77, 81, 88, 89, 90
Daily extremes and range in temperature of female birds on the nest during incubation period, 89
fluctuation in air temperature, 74, 89, 90, 93, 94
fluctuation in bird temperature, 74, 88, 89, 172
fluctuation in body temperature, 172
maximum air temperature, 80, 87, 90, 132
minimum air temperature, 43, 81, 89, 90, 132
range, see daily fluctuation
rhythm in air temperature, 79, 93, 132
rhythm in body temperature, 69, 76–91, 94, 132, 157, 167
rhythm in body temperature of passeriform birds, 157
rhythm in body temperature of young birds, 132
Darkness, effect of, 23, 24, 25, 26, 75, 93
Day, maximum egg temperature during, 147
median temperature during active, 69
Day temperature, 76, 77
Day to day, fluctuation in body temperature from, 72–76
Death point, upper thermal, 42
Dendroica aestiva aestiva, 10
Desert horned lark, 131, 168
Development of air-sacs, 110
of circulation of blood, 111
of endocrine regulation, 111
of nervous regulation, 111
of nervous system, 110
of temperature control, 6, 56, 106, 107, 108–113, 125, 130, 159, 168
of temperature control in young birds, 103, 108–113, 168
of temperature control mechanism, 123, 124, 143
Distribution of birds, 6
Diurnal birds, 77, 91
Diving bird, 171
Dog, 50, 127
Domestic animals, 167
chickens, 111
chickens, young, 111
fowl, 148, 164, 166, 171
fowl, eggs of, 138, 141, 165
fowl, respiration of, 106
hen, 75, 76
pigeon, 149
Domesticated bird, 148
domesticus, Gallus, 165
Passer domesticus, 10
domesticus domesticus, Passer, 10
Dougherty, John Edwin, 142, (bibliog.) 165
Dove, 37, 40, 56, 69, 77, 103
eastern mourning, 9, 13, 49
mourning, 28
ring, 28, 38, 40, 77, 96
Downing, A. C.; Gerard, R. W.; and Hill, Archibald Vivian, 34, (bibliog.) 165
Downy woodpecker, northern, 10, 13, 27, 33, 35, 36, 49, 53
Dry bulb thermometer, 43
Dryobates pubescens medianus, 10
villosus villosus, 10
Duck, 77
Dumetella carolinensis, 10
Dworkin, Samuel; and Finney, William Harper; Cassidy, G. T., 97, (bibliog.) 164

Eastern bluebird, 10, 13, 33
bob-white, 9, 13, 49
cardinal, 10, 49
chipping sparrow, 10, 25, 27, 28, 29, 30, 33, 35, 36, 38, 41, 49, 53, 55, 66, 70, 71, 88, 89, 91, 92
cowbird, 10, 49
crow, 10, 13, 35, 36
field sparrow, 10, 49
hairy woodpecker, 10, 27, 35, 36, 53
house wren, 8, 9, 10, 11, 13, 23, 27, 29, 30, 32, 33, 35, 36, 37, 40, 41, 46, 49, 50, 51, 52, 55, 56, 57, 58, 60, 62, 64, 66, 69, 70, 71, 87, 88, 89, 90, 99, 103, 106, 114, 137, 145, 149, 153, 155, 156, 160
house wren, behavior of adult, 145
house wren, optimum incubation temperature for, 160
house wren, respiration of, 156
house wren, skin temperature of, 57–58
house wren, young, 112, 119, 126, 158, 159
house wren's eggs, 138, 139, 143, 160
house wren's eggs, fluctuation of temperature of, 134

house wren's eggs, temperature of, 160
house wren's embryo, 150
mourning dove, 9, 13, 49
phoebe, 10, 13, 33, 149
robin, 10, 13, 27, 28, 32, 33, 35, 36, 52, 55, 66, 69, 70, 71, 87, 88, 89, 90, 137, 149
robin's eggs, 138, 139
song sparrow, 10, 33, 35, 36, 38, 49, 66, 70, 71, 88, 89, 91, 137
wood pewee, 10, 66, 70, 71, 75, 88, 89
yellow warbler, 10, 13, 33, 52, 55
Ecological point of view, 8–10
Edwards, Charles Lincoln, 141, (bibliog.) 165
Edwards, William Frederic, 5, 42, 94, 98, 105, 106, (bibliog.) 165
Effect of absence of bird on temperature of nest, 151, 152
of absence of incubating parents, 107
of age, 107, 120, 123, 124, 142, 159, 160, 169
of age on body temperature, 107
of age on resistance to low temperature, 142
of anaesthetics, 93, 94, 103, 158
of attentiveness, 18, 19, 131, 132, 156, 158, 159
of brooding of parent bird, 151, 152
of continuous low body temperature, 126
of damp, cold weather, 113
of darkness, 24, 25, 26, 75, 93
of desertion of nest by adult house wren, 141
of digestion and absorption of food, 158
of emotional excitement, 22, 29, 31, 33, 34, 59, 66, 81, 90, 91, 93, 155
of evaporation from surface of eggs, 136, 138
of exertion, 93
of exposure to high air temperatures on the hatching of the eastern house wren's eggs, 140
of fatigue, 107
of feathers, 25, 56, 59, 60, 61, 97, 98, 99, 100, 113, 120, 121, 158, 159
of fluctuation of air temperature on eggs, 134, 135
of fluctuations in air temperature, 42–45, 61, 64, 117, 119, 132, 156
of fluffing feathers, 47, 63, 98, 99
of food, 23, 29, 37–42, 90, 95, 124, 156, 158, 162
of forming of embryo in eggs, 138
of growth of feathers, 110, 113
of handling of birds, 24, 25, 107
of heat, 162
of heat generated by embryo, 159, 160
of heat radiation, 130
of high air temperature, 96, 117–121, 139–141, 158
of high and low air temperatures on the body temperature of the immature eastern house wren, 119
of high temperature, 123
of hunger, 107
of illness, 107
of inactivity, 90, 93
of inattentiveness, 19, 156, 157, 158, 159
of ingesting cold masses of food, 107, 130
of lack of food, 24, 37–42, 69, 80, 96, 126
of light, 25, 26, 75, 76, 77, 81, 91, 92, 93
of loss of feathers, 56, 58, 59, 96, 98, 148
of low air temperature, 7, 96, 119, 121–124, 141–144, 158, 163
of mental activity, 90, 158
of metabolism of embryo in eggs, 138
of muscular activity, 19, 22, 29, 31, 32, 33, 34–37, 38, 40, 41, 42, 44, 54, 59, 66, 67, 69, 74, 75, 76, 77, 80, 81, 90, 91, 94, 95, 107, 155, 156, 158
of pigmentation of feathers, 99–100
of position of bird on nest, 152
of prolonged exposure to low temperature, 127
of quiet, 130
of quiet of night, 80, 90, 91
of relaxation, 54
of respiration, 130
of rest, 77, 84, 158
of room temperature on accuracy of recording potentiometer, 20
of seasonal changes on body temperature, 171
of shape of nest, 152
of shivering, 40, 100
of size of body, 109, 120, 124
of starvation, 37–42, 123, 126, 127, 156, 158
of structure of nest, 152

of thrusting cold thermometer into young bird, 13
of too high temperature in incubator, 139
of too low temperature in incubator, 139
of urethane, 93
on hatching of the exposure of the eastern house wren's eggs for various lengths of time to air temperatures of 60° to 70° F. (15.6° to 21.1° C.) and relative humidities of 80% to 90%, 143
Egg and air temperatures, difference between, 133, 136
in the nest, fluctuation of internal temperature of house wren's, 150
temperature, 21, 133–154, 159
temperature during day, maximum, 147
temperature in the nest, fluctuation of, 145–148
temperature under experimental conditions, fluctuation in, 134–139
Eggs, 16, 18, 23, 56, 62, 63, 64, 66, 67, 69, 75, 76, 79, 133–154
artificial incubation of, 149, 150
eastern house wren's, 134, 138, 139, 140, 143, 160
eastern robin's, 138, 139
eastern song sparrow's, 139
effect of evaporation from surface of, 136, 138
effect of fluctuation of air temperature on, 134, 135
effect of forming of embryo in, 138
effect of metabolism of embryo in, 138
fluctuations of temperature of eastern house wren's, 134
hen's, 133, 134, 138, 141, 142
house wren's, 138, 139, 143, 149, 150, 151
loss of fertility of, 142
loss of weight in house wren's, 136, 138
minimum temperature of, 147
natural incubation of, 150
optimum incubation temperature for, 142, 148, 151
optimum incubation temperature for house wren's, 149, 150
temperature of, 133–154
temperature of eastern house wren's, 160
temperature of fertile, 133
temperature of hen's, 133, 134, 138, 170
temperature of infertile, 133
time of hatching of, 140
Eggs and nest, temperature of, 133–154
during incubation, temperature of, 133–154
of domestic fowl, 138, 141, 165
to low temperature, resistance of, 143, 144
will hatch, upper thermal limit at which, 139
Embryo, 133, 134, 135, 136, 138, 139–144, 145, 149, 150, 151, 154, 160
eastern house wren's, 150
Embryo in eggs, effect of forming of, 138
in eggs, effect of metabolism of, 138
in saline solution, house wren's, 141
Embryology, 169
Embryos to high temperature, resistance of, 139–141
Embryos to low temperature, resistance of, 160
Embryos to low air temperature, resistance of, 141–144
Emotional excitement, effect of, 22, 29, 31–34, 59, 66, 81, 90, 91, 93, 155
Endocrine glands, 95, 96, 97, 164
regulation, development of, 111
English sparrow, 10, 33, 41, 91, 98
sparrow, young, 13
erythrophthalmus, Pipilo erythrophthalmus, 10
erythrophthalmus erythrophthalmus, Pipilo, 10
Estabrook, G. B.; Karrer, Sebastian, and, 15, (bibliog.) 167
Evaporation from surface of eggs, effect of, 136, 138
of water from skin of young house wrens, 122
Excitement, effect of emotional, 22, 29, 31–34, 59, 66, 81, 90, 91, 93, 155
Exertion, effect of, 93
Experimental control and reversal of daily temperature rhythm, 91–94
Exposure to low temperature, effect of prolonged, 127
Eycleshymer, Albert Chauncey, 133, 138, 148, (bibliog.) 165

Fahrenheit scale, 12, 18
Fall in body temperature of birds when held in hand after capture, 35–36
Fat, 37, 95

Fat metabolism, 38
Fatigue, effect of, 107
Feathers, effect of, 25, 56, 59, 60, 61, 97, 98, 99, 100, 113, 120, 121, 158, 159
  effect of fluffing, 47, 63, 98, 99
  effect of growth of, 110, 113
  effect of loss of, 56, 58, 59, 96, 98, 148
  effect of pigmentation of, 99–100
Féré, Charles, 37, (bibliog.) 166
Fetus, 105, 161
Field sparrow, eastern, 10, 49
Finney, William Harper; Cassidy, G. T.; Dworkin, Samuel, and, 97, (bibliog.) 164
Fisher, W. S.; Riddle, Oscar, and, 97, (bibliog.) 171
Flicker, northern, 10, 13, 33
Fluctuation in air temperature, 20, 21, 42–45, 61, 64, 89, 90, 93, 123, 124, 130, 132, 136, 147, 157, 170
  in air temperature, daily, 89, 90, 93, 94
  in air temperature on eggs, effect of, 134, 135
  in bird temperature, daily, 74, 88, 89, 172
  in body temperature, seasonal, 76, 97
  in body temperature from day to day, 72–76
  in body temperature of birds, 7, 13, 22, 29, 34, 35, 38, 42, 43, 63, 72–76, 88, 90, 116, 155, 157
  in body temperature of passeriform bird, 155
  in egg temperature under experimental conditions, 134–139
  in passeriform bird temperature, greatest normal, 158
  in standard temperature, 29, 30
  in temperature, 16, 18, 22
  in temperature of eastern house wren's eggs, 134
  in temperature of nest, 151–154
  in temperature of sparrows, seasonal, 42
  in temperature of young bird, 132
  of egg temperature in the nest, 145–148, 150
  of internal temperature of house wren's egg in nest, 150
  of nest temperature, 150, 151–154
  of standard temperature, 29, 30
  of standard temperature with season, 29, 30
  of temperature, 16, 18, 22
Fluctuations in air temperature, effect of, 42, 45, 61, 64, 117, 119, 120, 132, 156
Fluffing feathers, effect of, 47, 63, 98, 99
Flycatcher, northern crested, 10, 13, 33, 149
Food, effect of, 23, 29, 37–42, 90, 95, 124, 156, 158, 162
  effect of ingesting cold masses of, 107, 130
  effect of lack of, 24, 37–42, 69, 80, 96, 126
Food and starvation, effect of, 37–42
Fowl, 100
  domestic, 148, 164, 166
  eggs of domestic, 165
  respiration of domestic, 106
  rise in temperature of domestic, 37
Fox, Edward L.; Benedict, Francis Gano, and 28, (bibliog.) 162

Galbraith, J. J.; Simpson, Sutherland, and, 22, 29, 77, 91, (bibliog.) 172
gallus, Gallus, 171
Gallus domesticus, 165
  gallus, 171
Galvanometer, 17, 21, 136
  sensitive, 21
Game bird, 148
Gamgee, Arthur, 15, (bibliog.) 166
Gardner, Leon Lloyd, 106, 107, (bibliog.) 166
Gathering net, 23
Gavarret, Jules, 5, 94, (bibliog.) 166
Geese, 103
General metabolism, 96
Geothlypis trichas brachidactyla, 10
Gerard, R. W.; and Hill, Archibald, Vivian; Downing, A. C., 34 (bibliog.) 165
Gesell, Robert, 34, (bibliog.) 166
Gland, adrenal, 97, 102
  endocrine, 96, 97, 164
  seasonal enlargement of thyroid, 97
  thyroid, 97, 163, 165
Gordon, Mervyn Henry; and Warren, Richard; Pembrey, Marcus Seymour, 106, (bibliog.) 170
Gradients in nest, temperature, 152, 154, 160
Gray, Carolyn Elizabeth; Kimber, Diana Clifford, and, 105, (bibliog.) 168
Great horned owl, 107

Greatest normal fluctuation in passeriform bird temperature, 158
Groebbels, Franz, 5, 37, 40, 42, 77, 96, 111, (bibliog.) 166
Gross, Alfred Otto, 124, (bibliog.) 166
Guinea-pig, 107
young, 106
Gullet temperature, 113

Hadwen, Seymour, 100, (bibliog.) 167
Haines, W. T.; Mitchell, Harold Hanson; Card, Leslie Ellsworth, and, 111, 112, (bibliog.) 169
Hairy woodpecker, eastern, 10, 27, 35, 36, 53
Handling of birds, effect of, 24, 25, 107
Hard maple-beech association, 9
Hári, Paul, 103, (bibliog.) 167
Harrold, Cyril Guy; Cartwright, Bertram William, and, 100, (bibliog.) 164
Hawk, red-tailed, 107
Heat, control of loss of, 111
effect of, 162
Heat control mechanism in man, 105, 106
metabolism, 100
of sun, resistance of young house wren to, 121
Heilmann, Gerhard, 100, (bibliog.) 167
Hen, 134
domestic, 75, 76
temperature of, 133, 148
Hen's eggs, 133, 134, 138, 141, 142
eggs, temperature of, 133, 134, 138
Hibernating mammals, 7, 114
High air temperature, effect of, 96, 119, 158
air temperature, survival at, 159
air temperatures, 76, 140, 171
and low temperatures, survival time of young birds at, 124–127
body temperature, 44, 45, 47, 51, 54, 76, 77, 139
body temperature, normal, 126
temperature, effect of, 123
temperature, resistance of embryos to, 139–141
temperature, resistance of young birds to, 117–121
temperature in incubator, effect of too, 100, 139
Highest, see also maximum
normal body temperature in passeriform birds, 158
rate of respiration in young birds, 115
temperature of attentive period, 68, 70, 78, 156
Hildén, Armas, 5, (bibliog.) 167
Hildén, Armas, and Stenbäck, K. S., 5, 77, 91, 93, (bibliog.) 167
Hill, Archibald Vivian; Downing, A. C.; Gerard, R. W.; and, 34, (bibliog.) 165
Hill, Leonard Erskine, 94, (bibliog.) 167
Historical account, 5–6
Homoiothermal animals, see warm-blooded animals
condition, stable, 126
mammals, 77
Homoiothermic, see homoiothermal
Horned lark, desert, 131
Horned owl, great, 107
House wren, 11, 22, 26, 28, 29, 32, 36, 38, 41, 45, 54, 55, 57, 60, 61, 62, 63, 67, 69, 74, 80, 112, 116, 117, 123, 124, 127, 131, 148, 159, 163, 172
wren, behavior of adult eastern, 145
wren, eastern, 8, 9, 10, 11, 13, 23, 27, 29, 30, 32, 33, 35, 36, 37, 40, 41, 46, 49, 50, 51, 52, 53, 55, 56, 57, 58, 60, 62, 64, 66, 69, 70, 71, 87, 88, 89, 90, 99, 103, 106, 114, 137, 145, 149, 153, 155, 156, 160
House wren, effect of desertion of nest by adult, 141
wren, evaporation of water from skin of young, 122
wren, loss of weight in young eastern, 126, 127
wren, maximum body temperature of birds other than, 33
wren, nesting behavior of, 162
wren, Ohio, 10
wren, Ohio subspecies of, 8
wren, optimum incubation temperature for eastern, 160
wren, respiration of eastern, 156
wren, skin temperature of eastern, 57–58
wren, skin temperature of young, 131
wren, upper lethal body temperature of, 141
wren, young, 103, 107, 108, 112, 114, 115, 117, 119, 123, 126, 127, 128, 129, 131, 138, 159, 168
wren, young eastern, 112, 119, 126, 159
wren to heat of sun, resistance of young, 121
wren's eggs, 138, 139, 143, 149, 150, 151

wren's eggs, eastern, 138, 139, 140, 143, 160
wren's eggs, fluctuation of temperature of eastern, 134
wren's eggs, loss of weight in, 136, 138
wren's eggs, optimum incubation temperature for, 149, 150
wren's eggs, temperature of eastern, 160
wren's eggs in the nest, fluctuation of internal temperature of, 150
wren's embryo in saline solution, 141
wren's nest, temperature of bottom and back of, 151, 152, 153
wren's nest, temperature of top of, 151, 153
Howell, William Henry, 127, (bibliog.) 167
Human skin, temperature of, 59, 163
Humidity, 117, 124, 137, 143, 149, 150
air, 43, 44, 143, 149, 150
Hummingbird, ruby-throated, 9, 13
Hunger, effect of, 107
Hylocichla mustelina, 10
Hyperpyrexia, 113
Hyperthyroidism, 165

Illanes, Armando; Lipschutz, Alexandre, and, 142, (bibliog.) 169
Illness, effect of, 107
Immature, see young
Inactivity, effect of, 90, 93
Inattentive period, 23, 64, 65, 66, 67, 68, 70, 75, 127, 128, 129, 130, 147, 148, 153, 162
period, initial temperature of, 67, 68, 71
period, last temperature of, 67, 68, 71
period, median temperature of, 68, 71, 78, 156, 157
Inattentiveness, effect of, 19, 156, 157, 158, 159
period of, see inattentive period
Incubating bird, body temperature of, 64–72, 148, 149, 154, 156, 157
bird, temperature of, 148, 149
parents, effect of absence of, 107
Incubation, 6, 29, 54, 56, 59, 61, 62, 63, 64–72, 75, 78, 79, 101, 106, 133–154, 159, 160, 165, 168, 171
average temperature of female birds on nest during, 64–72
temperature of, 148–152
temperature of eggs during, 133–154
Incubation of eggs, artificial, 149
period, 89, 133, 163
period, length of, 148
temperature for eastern house wren optimum, 149, 150, 160
temperature for eggs, optimum, 142, 148, 149, 151
Incubator, 49, 50
effect of too high temperature in, 139
effect of too low temperature in, 139
temperature, 136, 139, 149, 150
Indicator potentiometer, 21, 24, 26, 43, 56, 62, 64, 67, 92, 128, 134
potentiometer pyrometer, 155
Initial body temperature, 35, 39
temperature of attentive period, 67, 68, 70, 71, 78, 156
Insectivorous birds, 38
Insects, 37, 75, 101
Instruments used, 12–21
Internal body temperature, 15, 16, 57, 58, 59, 168
body temperature of man, 15
Introduction (Temperature of Birds), 5–10

Johnson, Alice; Benedict, Francis Gano; Miles, Walter Richard, and, 59, (bibliog.) 163
Johnson, C. H., 6
Junco, 42
Juvenile, see young

Kallir, Eva, 56, (bibliog.) 167
Karrer, Sebastian, and Estabrook, G. B., 15, (bibliog.) 167
Katabolism, 163
Kelso, Leon, 131, (bibliog.) 168
Kendeigh, Samuel Charles, 6, 99, (bibliog.) 168
Kendeigh, Samuel Charles, and Baldwin, Samuel Prentiss, 6, 13, 15, 22, 64, 103, 106, 107, 108, 110, 113, 121, 128, (bibliog.) 162, (bibliog.) 168
Samuel Charles; Baldwin, Samuel Prentiss, and, Physiology of the Temperature of Birds, 1–173
Killdeer, 9, 149
Kimball, Arthur Lalanne, 14, (bibliog.) 168
Kimber, Diana Clifford, and Gray, Carolyn Elizabeth, 105, ((bibliog.) 168

Kirkpatrick, William F.; Lamson, George Henry, Jr., and, 139, 141, 142, (bibliog.) 168
Kramer, T. C., 6
Krogh, August, 23, (bibliog.) 168
Kumagawa, Muneo, 127
Laboratories, Brush, 6
Laboratory, 12, 23
Baldwin Bird Research, 11, 12

Lack of food, effect of, 24, 37–42, 69, 80, 96, 126
Lamson, George Henry, Jr., and Kirkpatrick, William F., 139, 141, 142, (bibliog.) 168
Lark, desert horned, 131
Larsell, Olaf; Locy, William Albert, and, 101, 111, (bibliog.) 169
Last temperature of attentive period, 67, 68, 70, 78, 157
temperature of inattentive period, 67, 68, 71
Lavoisier and Sequin, 37
Leichtentritt, Bruno, 106, (bibliog.) 168
Length of incubation period, 148
Lethal air temperature, 117–119
bird temperature, 117–119
body temperature, 45–50, 120
body temperature, lower, 47–50, 123, 142, 144, 156, 159
body temperature, upper, 45–47, 52, 54, 123, 141, 156, 159
body temperature of house wren, upper, 141
body temperature of young birds, low, 124
temperature of young birds, upper, 119
Light, effect of, 25, 26, 75, 76, 77, 81, 91, 92, 93
Lillie, Frank Rattray, (bibliog.) 168
Limit at which eggs will hatch, upper thermal, 139
of body temperature, lower, 44, 45, 50, 156
of body temperature, upper, 44, 47, 156
Lippincott, William Adams, 139, (bibliog.) 168
Lipschutz, Alexandre, and Illanes, Armando, 142, (bibliog.) 169
Locy, William Albert, and Larsell, Olaf, 101, 111, (bibliog.) 169
Loop thermocouple, 16, 56
Loss of feathers, effect of, 56, 58, 59, 96, 98, 148
of weight in house wren's eggs, 136, 138
of weight in young eastern house wren, 126, 127
Low air temperature, effect of, 75, 96, 99, 119, 121–124, 141–144, 158, 159, 160, 163, 171
air temperature, resistance of embryos to, 160
air temperature, survival at, 159
body temperature, 40, 41, 42, 47–50, 51, 53, 54, 76, 77, 123, 139, 156
body temperature, effect of continuous, 126
body temperature, resistance of young birds to, 143, 144
body temperature, resistance to, 160
lethal body temperature of young birds, 124
standard temperature, 26
temperature, effect of, 123, 163
temperature, effect of age on resistance to, 142
temperature, effect of prolonged exposure to, 127
temperature, resistance of eggs to, 143, 144
temperature, resistance of embryos to, 141–144
temperature, resistance of young birds to, 121–124
temperature in incubator, effect of too, 139
temperatures, survival time of young birds at high and, 124–127
Lower lethal body temperature, 47–50, 123, 142, 144, 156, 159
limit of body temperature, 44, 45, 50, 156
thermal limits for birds, 43
Lowest body temperature, see minimum
body temperature at night, 80
normal body temperature in passeriform birds, 158
temperature of attentive periods, 68, 70, 78, 156–157
Ludford, R. S.; Cramer, William, and, 97, (bibliog.) 165
Lusk, Graham, 5, 37, 41, 94, 96, 100, (bibliog.) 169
luteus, Colaptes auratus, 10
macroura carolinensis, Zenaidura, 9

Magnolia-bay forest association, 9
Magnolia-Tamala association, 9
Mammal temperature, 5, 7

Mammals, 7, 8, 41, 77, 94, 95, 96, 97, 100, 102, 105, 107, 114, 168, 172
hibernating, 7, 114
homoiothermal, 77
starvation in, 41
Man, 8, 15, 37, 54, 62, 77, 80, 95, 97, 105, 107, 161
body temperature of, 80, 162, 163
internal body temperature of, 15
maximum body temperature in, 80
minimum body temperature in, 80
rise in temperature of, 37
starvation in, 41
temperature rhythm in, 80
Marine, David, (bibliog.) 169
Martin, purple, 10, 13, 33
Martins, Charles Frederic, 29, (bibliog.) 169
Maximum, see also highest
Maximum air temperature daily, 80, 87, 90, 132
body temperature of birds, 33, 34, 46, 47, 69, 87, 88, 89, 90, 91, 109, 117, 119, 157
body temperature in man, 80
body temperature of birds other than house wren, 33
body temperature of passeriform birds, 157
body temperature of the eastern house wren, 32
body temperature of young bird, 132
daily bird temperature, 77, 79, 88, 89, 90
egg temperature during day, 147
metabolism, 113
rate of respiration, 54–55, 117
standard metabolism, 111
McCall, R.; Cramer, William, and, 97, (bibliog.) 165
Mean daily temperature, 77
Measurements, 29, 110
Mechanism, development of temperature control, 123, 124, 143
Mechanism of temperature control, 28, 40, 41, 42, 43, 47, 49, 51, 54, 56, 94–104, 113, 117, 123, 124, 143, 158, 162
Median daily bird temperature, 69, 71, 78, 157
temperature during active day, 69, 71, 157
temperature during night, 69, 71, 78, 157
temperature of attentive period, 68, 70, 71, 78, 157
temperature of inattentive period, 68, 71, 78, 157
medianus, Dryobates pubescens, 10
melodia, Melospiza melodia, 10
melodia melodia, Melospiza, 10
Melospiza melodia melodia, 10
Mercury thermometer, 12–14, 22, 32, 61, 76, 106, 107, 129, 149, 155
Metabolism, 7, 8, 26, 28, 29, 33, 34, 37, 38, 42, 44, 47, 55, 90, 95, 96, 97, 98, 111, 112, 126, 138, 162, 170, 171
basal, 22, 23, 171
body, 7, 105
carbohydrate, 38, 165
fat, 38
general, 96
heat, 100
maximum, 113
maximum standard, 111
normal, 122
protein, 38
standard, 22, 23, 26, 29, 31, 38, 40, 69, 90, 111, 112, 155, 156
Metabolism of birds, 5
of embryo in eggs, effect of, 138
of muscular tissue, 7, 95, 96
of nervous tissue, 34
Method [of obtaining temperature of bird on nest], 62–64
Methods of study, 11–21
Mice, 105, 170, 172
Migrating bird, 78
Migration of eastern house wren, 9
migratorius, Turdus migratorius, 10
migratorius migratorius, Turdus, 10
Miles, Walter Richard; and Johnson, Alice; Benedict, Francis Gano, 59, (bibliog.) 163
Mills, Clarence Alonzo, 97, (bibliog.) 169
Minimum, see also lowest
Minimum air temperature, daily, 43, 81, 89, 90, 132
bird temperteure, 81, 90
bird temperature, daily, 88
body temperature in man, 80
body temperature of birds, 50, 69, 78, 81, 87, 88, 89, 90, 91, 117, 119, 157
body temperature of passeriform birds, 157
body temperature of young bird, 132
daily bird temperature, 77, 81, 89, 90, 132
rate of respiration, 116
temperature of eggs, 147

Mitchell, Harold Hanson; Card, Leslie Ellsworth; and Haines, W. T., 111, 112, (bibliog.) 169
Molothrus ater ater, 10
Monotremes, 7
Moran, T., 134, 142, (bibliog.) 169
Mourning dove, 28, 171
dove, eastern, 9, 13, 49
Mouth, temperature of, 16
Müller, Bruno, 100, 101, (bibliog.) 170
Murray, John, 133, (bibliog.) 170
Muscular activity, effect of, 19, 22, 29, 31, 32, 33, 34–37, 38, 40, 41, 42, 44, 54, 59, 66, 67, 69, 74, 75, 76, 77, 80, 81, 90, 91, 94, 95, 107, 155, 156, 158
tissue, metabolism of, 7, 95, 96
mustelina, Hylocichla, 10
Myiarchus crinitus boreus, 10
Myiochanes virens, 10

Names of birds included in this study, scientific, 9–10
Natural incubation of eggs, 150
Neck, temperature of upper, 16
Nervous regulation, development of, 111
system, development of, 110
Nest, 11, 16, 18, 19, 23, 67, 72, 78, 79, 81, 87, 90, 107, 129, 130, 131, 139, 143, 144, 145, 160
Nest, effect of absence of bird on temperature of, 19, 151, 152
effect of position of bird on, 152
effect of shape of, 152
effect of structure of, 152
fluctuation in temperature of the, 151–154
fluctuation of egg temperature in the, 145–148
fluctuation of internal temperature of house wren's egg in, 150
method of obtaining temperatures of bird on, 62
temperature gradients in, 152, 154
temperature of bottom and back of house wren's, 151, 152, 153
temperature of bottom of, 128
temperature of eggs and, 133–154
temperature of front of, 152, 153
temperature of sides of, 152, 153
temperature of top of house wren's, 151, 153
Nest by adult house wren, effect of desertion of, 141
during incubation, average temperature of female on, 64–72
temperature, 16, 19, 87, 124, 150, 151–154, 158
temperature, fluctuation of, 160
Nesting behavior, 11, 63–64, 67, 80, 130, 148, 154, 162
Nestling, see young
Nestling birds, body temperature of, 105–132
Net, gathering, 23
Nickel, 15
Night, body temperature of bird at, 76, 77, 80, 147
effect of quiet of, 80, 90, 91
lowest body temperature at, 80
median temperature during, 69, 71, 78, 157
temperature fluctuation of young birds at, 131
Nocturnal bird, 77, 172
Non-passeriform bird, 32
Normal body temperature, 123
fluctuation in passeriform bird temperature, greatest, 158
high body temperature, 126
metabolism, 122
temperature, 31–50, 107
temperature of young birds in the nest, 127–132
Northern crested flycatcher, 10, 13, 33, 149
downy woodpecker, 10, 13, 27, 33, 35, 49, 53
flicker, 10, 13, 33
yellow-throat, 10, 49
Number of cases in which adult birds have recovered their normal temperature after their body temperature had been reduced experimentally to the indicated levels, 49
Nussmann, Theodora Clara; and Benedict, Francis Gano; Riddle, Oscar, 111, (bibliog.) 171
Nuthatch, white-breasted, 10, 35, 36, 53

Oak-chestnut association, 9
Oberholser, Harry Church, 6
Ohio house wren, 10
subspecies of house wren, 8
Optimum incubation temperature for eastern house wren, 160
incubation temperature for eggs, 142, 148
incubation temperature for house wren's eggs, 149

Owl, 77, 91
Oxyechus vociferus vociferus, 9

Palmiped bird, 169
Passer domesticus domesticus, 10
Passeriform bird, 22, 26, 33, 41, 42, 50, 61, 63, 64, 69, 70, 72, 75, 78, 155, 157, 158
  bird, fluctuation in body temperature of, 155
  bird temperature, greatest normal fluctuation in, 158
  birds, daily rhythm in body temperature of, 157
  birds, skin temperature of, 156
Passeriformes, 8, 13, 22, 61
passerina, Spizella passerina, 10
passerina passerina, Spizella, 10
Pembrey, Marcus Seymour, 5, 37, 42, 94, (bibliog.) 170
Pembrey, Marcus Seymour; Gordon, Mervyn Henry; and Warren, Richard, 106, (bibliog.) 170
Perch trap, 11
Period, attentive, 18, 19, 56, 64, 65, 66, 67, 68, 69, 70, 74, 75, 78, 127, 128, 129 130, 146, 147, 148, 153, 156, 157
  highest temperature of attentive, 68, 70, 78, 156
  inattentive, 19, 23, 64, 65, 66, 67, 68, 70, 75, 127, 128, 129, 130, 147, 148, 153, 162
  initial temperature of attentive, 67, 68, 70, 71, 78, 156
  initial temperature of inattentive, 67, 68, 71
  last temperature of attentive, 67, 68, 70, 78, 157
  last temperature of inattentive, 67, 68, 71
  lowest temperature of attentive, 68, 70, 78, 156–157
  median temperature of attentive, 68, 70, 71, 78, 157
  median temperature of inattentive, 68, 71, 78, 157
Period of attentiveness, see attentive period
Period of inattentiveness, see inattentive period
Periods of attentiveness and inattentiveness in various species of birds (females) whose body temperatures are given in Table XIV, 66
Perspiration, 97
Pewee, eastern wood, 10, 66, 70, 71, 75, 88, 89
Phoebe, eastern, 10, 13, 33, 149
phoebe, Sayornis, 10
Physiological behavior, 31
Physiological point of view, 7–8
Physiology of the Temperature of Birds, Baldwin, Samuel Prentiss, and Kendeigh, Samuel Charles, I–X, 1–173
Pincus, Gregory, 114, (bibliog.) 170
Pincus, Gregory; Stier, T. J. B., and, 105, (bibliog.) 172
Pinus associes, 9
Pigeon, 40, 69, 77, 96, 97, 100, 111, 149, 163, 164, 170, 171
  common, 38
Pigmentation of feathers, effect of, 99–100
Pipilo erythrophthalmus erythrophthalmus, 10
Poikilothermic animals, 7, 114
  (cold-blooded) stage in development of warm-blooded animals, 105–107, 158
  temperature of young bird, 158
Position of bird on nest, effect of, 152
Potentiometer, 74, 80
  indicator, 21, 24, 26, 43, 56, 62, 64, 67, 92, 128, 134
  recording, 15, 16–21, 62, 68, 78, 131, 155
Potentiometer pyrometer, indicator, 155
Prairie chicken, young, 124, 167
Progne subis subis, 10
Protein, 37, 38, 47, 95
Protein metabolism, 38
Protoplasm, 47, 109, 123, 138, 141, 143
pubescens medianus, Dryobates, 10
Puppies, young, 105
Purple martin, 10, 13, 33
Purpose of the study, 7
pusilla, Spizella pusilla, 10
pusilla pusilla, Spizella, 10
Pütter, August von, 5, 47, 94, (bibliog.) 170
Pyrometer, indicator potentiometer, 155

Quercus-Castanea association, 9
Querido, A.; Britton, Sidney William; and Bright, E. M.; Cannon, Walter Bradford, 97, (bibliog.) 164
Quiet, effect of, 80, 130
Quiet of the night, effect of, 80, 90, 91

Range, daily, see daily fluctuation
Range of temperature, see fluctuation of temperature
Rate of respiration, 156, 159
of respiratory movements at different body temperatures, 50–55
of respiratory movements in young birds, 114–117
Ratite bird, 172
Raudnitz, Robert W., 105, (bibliog.) 170
Recording potentiometer, 15, 16–21, 62, 68, 78, 131, 151, 155
potentiometer, effect of room temperature on accuracy of, 20
Rectal temperature, 76
Red-bellied woodpecker, 10, 13
Red-eyed towhee, 10, 49
Red-tailed hawk, 107
Regnault and Reiset, 100
Regulation, see control
development of endocrine, 111
development of nervous, 111
Reiset, Regnault, and, 100
Relation between skin and body temperatures, 131
between skin and internal body temperatures of the female eastern house wren at different air temperatures, 60
between temperature of eggs and that of surrounding air, 137
Relaxation, complete, 26
Research facilities, 11–12
Resistance of eggs to low temperature, 143, 144
of embryos to high temperature, 139–141
of embryos to low air temperature, 160
of embryos to low temperature, 141–144
of young birds to high air temperature, 113, 117–121
of young birds to high body temperature, 121, 139
of young birds to high temperature, 117–121
of young birds to low air temperature, 113, 121–124
of young birds to low body temperature, 121–124, 143, 144
of young birds to low temperature, 121–124
of young house wrens to heat of sun, 121
to low body temperature, 160
to low temperature, effect of age on, 142
Respiration, 26, 38, 47, 50, 54, 55, 59, 95, 101, 102, 107, 110, 111, 113, 117, 124, 158, 159, 161, 166, 168, 170, 172
bird, 103
effect of, 130
maximum rate of, 54–55, 117
minimum rate of, 116
rate of, 54–55, 156
Respiration of domestic fowl, 106
of eastern house wren, 156
of young birds, 110
of young birds, highest rate of, 115
Respiratory movements, see also respiration
movements at different body temperatures, rate of, 50–55
movements in young birds, rate of, 110, 114–117
system, 100
Rest, effect of, 77
Reversal of daily temperature rhythm, experimental control and, 91–94
Rhythm, experimental control and reversal of daily temperature, 91–94
Rhythm in air temperature, daily, 79, 93, 132
in body temperature, daily, 69, 76–91, 94, 132, 157, 167
in body temperature of passeriform birds, daily, 157
in body temperature of young birds, daily, 132
in man and other animals, temperature, 80
Richmondena cardinalis cardinalis, 10
Riddle, Oscar, 77, (bibliog.) 170
Riddle, Oscar; Benedict, Francis Gano, and, 38, 40, 69, 90, 96, (bibliog.) 163
Oscar; Christman G., and Benedict, Francis Gano, 28, 96, (bibliog.) 171
Oscar, and Fisher, W. S., 97, (bibliog.) 171
Oscar; Nussmann, Theodora Clara; and Benedict, Francis Gano, 111, (bibliog.) 171
Oscar; Smith, Guinevere C.; and Benedict, Francis Gano, 28, (bibliog.) 171
Ring dove, 28, 38, 40, 77, 96, 171
Rise in temperature of domestic fowl, 37
in temperature of man, 37

Robin, 69
eastern, 10, 13, 27, 28, 32, 33, 35, 36, 52, 55, 66, 69, 70, 71, 87, 88, 89, 90, 137, 149
Robin's egg, eastern, 138, 139
Room temperature, 19, 20, 21, 44, 60, 94, 98, 109
Rowan, 42
Rubner, 37, 95
Ruby-throated hummingbird, 9, 13
rufum, Toxostoma, 10

Sacci abdominalis, 100
cervicales, 100
intermedii anteriores, 100
intermedii posteriores, 100
Saccus interclavicularis, 100
Salts, 143
Sawyer, C. Baldwin, 6
Sayornis phoebe, 10
Scientific names of birds included in this study, 9–10
Sea birds, 22
Season, variation in standard temperature with, 30
Seasonal fluctuation in body temperature, 76, 97
fluctuation in temperature of sparrows, 42
Seebeck, 14
Self-registering thermometer, 133
Sensitive galvanometer, 21
Sequin, Lavoisier and, 37
Sex difference in standard temperature, 28–29
Shape of nest, effect of, 152
Shelford, Victor E., 6
Shivering, effect of, 40, 95
Simpson, Sutherland, 5, 22, 29, 31, 75, 76, 148, (bibliog.) 171
Simpson, Sutherland, and Galbraith, J. J., 22, 29, 77, 91, (bibliog.) 172
Sialia sialis sialis, 10
sialis, Sialia sialis, 10
sialis sialis, Sialis, 10
Sitta carolinensis carolinensis, 10
Size of body, effect of, 29, 100, 109, 120, 124
Skin, temperature of human, 59, 163
Skin and body temperatures, relation between, 131
temperature, 16, 56–61, 62, 63, 64, 97, 147, 151
temperature during breeding season, 61
temperature of passeriform birds, 156
temperature of the eastern house wren, 57–58
temperature of young house wren, 131
Smith, Guinevere C.; and Benedict, Francis Gano; Riddle, Oscar, 28, (bibliog.) 171
Snell, J. F.; Benedict, Francis Gano; and, 37, (bibliog.) 163
Song sparrow, eastern, 10, 33, 35, 36, 38, 49, 66, 70, 71, 88, 89, 91, 137
Song sparrow's eggs ,eastern, 139
Sparrow, 39, 42, 56, 98, 100
eastern chipping, 10, 25, 27, 28, 29, 30, 33, 35, 36, 38, 41, 49, 53, 55, 60, 70, 71, 88, 89, 91, 92
eastern field, 10, 49
eastern song, 10, 33, 35, 36, 38, 49, 66, 70, 71, 88, 89, 91, 137
English, 10, 33, 41, 91, 98
young, 106
young English, 13
Sparrow's eggs, eastern song, 139
Sparrows, seasonal fluctuation in temperature of, 42
Specific gravity of bird, 103, 104
Spizella passerina passerina, 10
pusilla pusilla, 10
Stable homoiothermal condition, 126
Standard metabolism, 22, 23, 26, 29, 31, 38, 40, 69, 90, 111, 112, 155, 156
metabolism, maximum, 111
temperature, 22–31, 33, 36, 38, 54, 55, 69, 112, 155, 156
temperature, constancy of, 29–31
temperature, low, 26
temperature, fluctuation in, 29, 30
temperature, sex difference in, 28–29
temperature, treatment of birds before determining, 23–25
temperature determined, 26–28
temperature of immature eastern house wren after establishment of temperature control, 112
temperature with season, variation in, 29, 30
temperatures of birds, 112
temperatures of young birds, 112
thermometer, 19, 20, 21
Starling, Ernest Henry, 5, 10, 93, 94, (bibliog.) 172
Starvation, effect of, 37–42, 96, 123, 126, 127, 156, 158
effect of food and, 37–42
Starvation in man, 41
in mammals, 41

Steel thermocouple, copper and, 15
Stenbäck, K. S.; Hildén, Armas,and, 5, 77, 91, 93, (bibliog.) 167
Stevenson, James, 6, 93
Stier, T. J. B., and Pincus, Gregory, 105, (bibliog.) 172
Stoner, Dayton, 22, 36, 131, (bibliog.) 172
Sturnus vulgaris vulgaris, 10
subis, Progne subis, 10
subis subis, Progne, 10
Summary and conclusions, 155
Summer temperature, 76
Sumner, Francis Bertody, 105, (bibliog.) 172
Sun temperature, 113
Survey, Biological, 12
Survival at high air temperature, 159
at low air temperature, 159
time and loss in weight of nestling eastern house wrens when confined without food at different air temperatures, 126–127
time of young birds at high and low temperatures, 124–127
Sutherland, Alexander, 22, 42, (bibliog.) 172
Sweat glands, 97
Swimming bird, 171

Talbot, Fritz Bradley; Benedict, Francis Gano, and, 105, (bibliog.) 163
Temperature, air, 19, 20, 21, 29, 30, 38, 40, 41, 42–45, 47, 49, 56, 59, 60, 61, 64, 72, 74, 75, 78, 90, 91, 93, 94, 96, 97, 98, 99, 105, 106, 107, 112, 113, 116, 117, 124, 126, 127, 130, 132, 133, 136, 137, 138, 139–144, 147, 151, 152, 154, 158, 172
belly, 57, 58, 60, 61, 63
body, 5, 7, 13, 14, 22–132, 138, 139, 146, 158, 159, 160, 166, 167, 171, 172
breast, 57, 58, 60, 61, 63
chemical control of body, 96
constancy of standard, 29–31
daily fluctuation in air, 74, 89, 90, 93
daily fluctuation in bird, 74, 88, 89, 172
daily maximum air, 43, 80, 81, 87, 89, 90, 132
daily rhythm in air, 79, 93, 132
daily rhythm in body, 69, 76–91, 94, 132, 157, 167
day, 76, 77
effect of age on resistance to low, 142
effect of continuous low body, 126
effect of fluctuations in air, 42–45, 61, 64, 132
effect of high, 123
effect of high air, 96, 119, 158
effect of low, 123, 163
effect of low air, 96, 144
effect of prolonged exposure to low, 127
egg, 21, 133–154, 159
fluctuation in, 16, 18, 22
fluctuation in air, 20, 21, 42–45, 61–64, 74, 89, 90, 91, 93, 123, 124, 130, 132, 136, 147, 156, 157, 170
fluctuation in standard, 29, 30, 90, 116, 157
fluctuation of nest, 160
greatest normal fluctuation in passeriform bird, 158
gullet, 113
high air, 76, 140, 171
high body, 44, 45, 47, 51, 54, 76, 77, 139
highest body, see maximum
initial, 67, 68, 78
internal body, 15, 16, 57, 58, 59, 168
lethal air, 117–119
lethal bird, 117–119
lethal body, 45–50, 120
low body, 40, 41, 42, 51, 54, 76, 77, 123, 139, 156
low standard, 26
lower lethal body, 47–50, 123, 142, 144, 156, 159
lower limit of body, 44, 45, 50, 156
lowest body, see minimum
mammal, 5, 7
maximum daily bird, 69, 77, 79, 88, 89, 90
median daily bird, 8, 69, 71, 78, 157
minimum daily bird, 77, 81, 88, 89, 90
nest, 16, 19, 87, 124, 150, 151–154
night, 76, 77
night body, 80
normal, 31–50, 107
normal body, 123
normal high body, 126
rectal, 76
resistance of eggs to low, 143, 144
resistance of embryos to high, 139–141
resistance of embryos to low, 141–144
resistance of embryos to low air, 160

resistance of young birds to low, 121–124
resistance of young birds to high, 117–121
resistance of young birds to high air, 113
resistance of young birds to low body, 143, 144
resistance to low body, 160
room, 19, 20, 21, 44, 60, 94, 98, 109, 136
seasonal fluctuations in body, 76, 97
sex difference in standard, 28–29
skin, 16, 56–61, 62, 63, 64, 97, 147, 151, 154
standard, 22–31, 33, 36, 38, 54, 55, 69, 112, 155, 156
summer, 76
sun, 113
survival at high air, 159
survival at low air, 159
treatment of birds before determining standard, 23–25
upper lethal body, 44, 45–47, 52, 54, 123, 141, 156, 159
upper limit of body, 44, 47
water, 20
winter, 76
Temperature at night, lowest body, 80
at proventriculus, 12, 16
control, 33, 59, 94–104, 106, 108–113, 114, 116, 117, 120, 156, 158, 161, 164, 168
control, basic, 112
control, development of, 6, 56, 106, 107, 108–113, 125, 130, 159, 168
control, mechanism of, 28, 40, 41, 42, 43, 47, 49, 51, 54, 56, 94–104, 113, 117, 123, 124, 143, 158, 162
control in young, 170
control in young, basic, 112
control in young birds, development of, 103, 108–113, 168
control mechanism, development of, 123, 124, 143
determined, standard, 26–28
during active day, median, 69, 71, 157
during breeding season, skin, 61
during day, maximum egg, 147
during night, median, 69, 71, 78, 157
fluctuation of young birds at night, 131
fluctuation of young birds during day, 130, 131
for eastern house wren, optimum incubation, 160
for eggs, optimum incubation, 142, 148, 149
for house wren's eggs, optimum incubation, 149–150
from day to day, fluctuation in body, 72–76
gradients in nest, 152, 154, 160
in anal opening, 12, 14
in cloaca, 77
in groin, 134
in incubator, effect of too high, 139
in incubator, effect of too low, 139
in man, maximum body, 80
in man, minimum, 80
in passeriform birds, daily rhythm in body, 157
in rectum, 14
in the nest, fluctuation of egg, 145–148
in throat, 12, 14, 24, 38, 40, 43, 94
of adult birds, body, 13, 22–104
of animal, body, 166
of attentive period, highest, 68, 70, 78, 156
of attentive period, initial, 67, 68, 70, 71, 78, 156
of attentive periods, last, 67, 68, 70, 78, 157
of attentive period, lowest, 68, 70, 78, 156–157
of attentive period, median, 68, 70, 71, 78, 157
of back, 57
of bird at night, body, 76, 77, 80,147
of birds, I–X, 1–173
of birds, body, 22–132, 155, 172
of birds, fluctuation in body, 7, 13, 22, 29, 34, 35, 38, 42, 43, 68, 72–76, 88, 90, 116, 155, 157
of birds immediately after killing, 22, 31
of birds, maximum body, 33, 34, 36, 46, 47, 69, 87, 88, 89, 90, 91, 109, 117, 119, 157
of birds, minimum body, 50, 69, 78, 81, 87, 88, 89, 90, 91, 119, 157
of birds on nest, 89
of birds on nest, method of obtaining, 62
of birds other than house wren, maximum body, 33
of birds under natural conditions, body, 61–64
of bottom and back of house wren's nest, 151, 152, 153
of bottom of nest, 128
of different parts of the nest of the

eastern house wren both when the bird is incubating and when it is off the nest, 153
of domestic fowl, rise in, 37
of eastern house wren's egg, 160
of eastern house wren's egg, fluctuation in, 134
of eggs, 133–154
of eggs, effect of fluctuation of air temperature on, 134, 135
of eggs and nest, 133–154
of eggs during incubation, 133–154
of eggs, minimum, 147
of female birds on nest during incubation, average, 64–72
of fertile eggs, 133
of front of nest, 152, 153
of hen, 133, 148
of hen's eggs, 133, 134, 138, 170
of house wren, upper lethal body, 141
of house wren's egg in the nest, fluctuation of internal, 150
of human skin, 59, 163
of incubating bird, body, 64–72, 148, 149, 154, 156, 157
of incubation, 148–151
of inattentive period, last, 67, 68, 71
of inattentive period, median, 68, 71, 78, 157
of infertile eggs, 133
of lower animals, 15
of man, body, 162
of man, internal body, 15
of man, rise in, 37
of mouth, 16
of neck, 16
of nest, 134–154, 158
of nest, effect of absence of bird on, 151, 152
of passeriform bird, fluctuation in body, 155
of passeriform birds, skin, 156
of side of body, 57
of sides of nest, 152, 153
of sparrows, seasonal fluctuation in, 42
of the eastern house wren, skin, 57–58
of the nest, fluctuation in, 151–154
of throat, 94
of top of house wren's nest, 151, 153
of upper neck, 16
of young altricial bird, body, 166
of young birds, body, 105–132, 138
of young birds, daily rhythm in body, 132
of young birds, low lethal body, 124
of young birds, maximum body, 132
of young birds, minimum body, 132
of young birds, standard, 112
of young birds, upper lethal, 119
of young birds in the nest, 159
of young birds in the nest, normal, 127–132
of young house wren, skin, 131
on accuracy of recording potentiometer, effect of room, 20
regulation, see temperature control
rhythm, experimental control and reversal of daily, 91–94
rhythm in man and other animals, 80
under wing, 12
with season, variation in standard, 29, 30
Temperatures, difference between egg and air, 133, 136
high, 76, 140, 171
rate of respiratory movements at different body, 50–55
relation between skin and body, 131
survival time of young birds at high and low, 124–127
Thermal death point, upper, 42
limit at which eggs will hatch, upper, 139
Thermocouple, 12, 14–16, 18, 21, 24, 25, 26, 32, 38, 40, 43, 44, 56, 60, 62, 63, 64, 72, 78, 80, 92, 94, 131, 135, 136, 142, 145, 155, 168
copper and steel, 15
copper-constantan, 15, 56, 155
loop, 16, 56
thread, 16, 62, 63, 64, 128, 145, 152
Thermocouple thermometer, 15, 16, 24, 127, 134, 145
Thermograph, air, 78
Tycos, 72
Thermometer, 12, 13, 77, 121, 133, 134, 148, 161
clinical, 12, 36
dry bulb, 43
into young bird, effect of thrusting cold, 13
mercury, 12, 13, 14, 22, 32, 61, 76, 106, 107, 129, 149, 155
self-registering, 133
standard, 19, 21
thermocouple, 15, 16, 24, 127, 134, 145
wet bulb, 43
Thrasher, brown, 10, 49
Thread thermocouple, 16, 62, 63, 64, 128, 145, 152

Throat, temperature in, 12, 14, 24, 38, 40, 43, 94
Thrush, wood, 10, 66, 70, 71, 88, 89
Thyroid gland, 97, 163, 165, 169
gland, seasonal enlargement of, 97
Time of daily maximum and minimum bird temperature, 88
Towhee, red-eyed, 10, 49
Toxostoma rufum, 10
Trap perch, 11
Treatment of birds before determining standard temperature, 23–25
trichas brachidactyla, Geothlypis, 10
Troglodytes aedon aedon, 8, 9, 10, 155, 163
Turdidae, 22
Turdus migratorius migratorius, 10
Turkey vulture, 107
Tycos thermograph, 72

Upper lethal body temperature, 45–47, 52, 54, 123, 141, 156
lethal body temperature of house wren, 141
lethal temperature of young birds, 119
limit of body temperature, 44, 47
neck, temperature of, 16
thermal death point, 42
thermal limit at which eggs will hatch, 139
Urethane, effect of, 93

van't Hoff's law for chemical reactions, 125–126
Variation, see fluctuation
Variation in standard temperature with season, 29, 30
Victorow, Constantin, 103, (bibliog.) 172
villosus, Dryobates villosus, 10
villosus villosus, Dryobates, 10
virens, Myiochanes, 10
virginianus, Colinus virginianus, 9
virginianus virginianus, Colinus, 9
vociferus, Oxyechus vociferus, 9
vociferus vociferus, Oxyechus, 9
Voit, 96
vulgaris, Sturnus vulgaris, 10
vulgaris vulgaris, Sturnus, 10
Vulture, turkey, 107

Warbler, eastern yellow, 10, 13, 33, 53, 55
Warm-blooded animals, 5, 7, 47, 50, 94, 95, 105, 107, 143, 163
animals, poikilothermic (cold-blooded) stage in development of, 105–107
Warren, Richard; Pembrey, Marcus Seymour; Gordon, Mervyn Henry, and, 106, (bibliog.) 170
Water temperature, 20
Waxwing, cedar, 10, 66, 70, 71, 88, 89, 149
Weather, effect of damp, cold, 113
Weight in house wren's eggs, loss of, 136, 138
in young eastern house wren, loss of, 126, 127
Wet bulb thermometer, 43
Wetmore, Alexander, 5, 12, 22, 29, 31, 42, 77, 102, 106, (biblog.) 172
White-breasted nuthatch, 10, 35, 36, 53
Wiggars, Dr. C. J., 6
Winter temperature, 76
Woodpecker, 26, 32, 55
eastern hairy, 10, 27, 35, 36, 53
northern downy, 10, 13, 27, 33, 35, 49, 53
red-bellied, 10, 13
Worley, Leonard G., 6
Wood pewee, eastern, 10, 66, 70, 71, 75, 88, 89
thrush, 10, 66, 70, 71, 88 89
Wren, behavior of adult eastern house
Wren, eastern house, 8, 9, 10, 11, 13, 23, 27, 29, 30, 32, 33, 35, 36, 37, 40, 41, 46, 49, 50, 51, 52, 55, 56, 57, 58, 60, 62, 64, 66, 69, 70, 71, 87, 88, 89, 90, 99, 103, 106, 114, 137, 145, 149, 153, 155, 156, 160
Wren, effect of desertion of nest by adult house, 141
evaporation of water from skin of young house, 122
house, 11, 22, 26, 28, 29, 32, 36, 38, 41, 45, 54, 55, 57, 60, 61, 62, 63, 67, 69, 74, 80, 112, 116, 117, 123, 124, 127, 131, 148, 159, 163, 172
loss of weight in young eastern house, 126, 127
maximum body temperature of birds other than house, 33
nesting behavior of house, 162
Ohio house, 10
Ohio subspecies of house, 8
optimum incubation temperature for eastern house, 160
respiration of eastern house, 156
skin temperature of eastern house, 57–58

skin temperature of young house, 131
upper lethal body temperature of house, 141
young eastern house, 112, 119, 126, 159
young house, 11, 103, 107, 108, 112, 114, 115, 117, 119, 123, 126, 127, 128, 129, 131, 138, 159, 168
young, 110
Wren's egg, temperature of eastern house, 160
eggs, eastern house, 134, 138, 139, 140, 143, 160
eggs, fluctuation of temperature of eastern house, 134
eggs, house, 138, 139, 143, 149, 150, 151
eggs, loss of weight in house, 136, 138
eggs, optimum incubation temperature for house, 149, 150
eggs in the nest, fluctuation of internal temperature of house, 150
nest, temperature of bottom and back of house, 151, 152, 153
nest, temperature of top of house, 151, 153
Wrens to heat of sun, resistance of young house, 121

Yellow warbler, eastern, 10, 13, 33, 53, 55
Yellow-throat, northern, 10, 49
Young, basic temperature control of, 112
temperature control in the, 170
Young altricial bird, 111
altricial bird, body temperature of, 166
bird, altricial, 111
bird, effect of thrusting cold thermometer into, 13
bird, fluctuation of temperature of, 132
bird, maximum body temperature of, 132
bird, minimum body temperature of, 132
birds, body temperature of, 105–132, 138
birds, cold-blooded stage in, 125
birds, daily rhythm in body temperature of, 132
birds, development of temperature control in, 103, 108–113
birds, highest rate of respiration in, 115
birds, low lethal body temperature for, 124
birds, rate of respiratory movements in, 114–117
birds, respiration in, 110
birds, standard temperature of, 112
birds, upper lethal temperature of, 119
birds at high and low temperatures, survival time of, 124–127
birds at night, temperature fluctuation of, 131
birds in the nest, normal temperature of, 127–132
birds to high air temperature, resistance of 113, 117–121
birds to high body temperature, resistance of, 121, 139
birds to high temperature, resistance of, 117–121
birds to low air temperature, resistance of, 113, 121–124
birds to low body temperature, resistance of, 121–124, 143, 144
birds to low temperature, resistance of, 121–124
Young blackbird, 106
chickens, 106, 111
eastern house wren, 112, 119, 126, 158, 159
eastern house wren, loss of weight in, 126, 127
English sparrow, 13
goat, 106
guinea-pig, 106
house wren, 103, 107, 108, 112, 114, 115, 117, 119, 123, 126, 127, 128, 129, 131, 138, 159, 168
house wren, skin temperature of, 131
house wrens, evaporation of water from skin of, 122
house wrens to heat of sun, resistance of, 121
mice, 114
prairie chicken, 124
puppies, 105
sparrow, 106
wrens, 110

Zenaidura macroura carolinensis, 9

CONTRIBUTIONS FROM THE BALDWIN BIRD RESEARCH LABORATORY

For convenience in reference and library use there are listed below the published papers from the Baldwin Bird Research Laboratory produced by S. Prentiss Baldwin, his assistants, and collaborators.

CONTRIBUTION No. 1.—BALDWIN, S. PRENTISS. **Bird Banding by Means of Systematic Trapping.** Abstract of the Proceedings of the Linnaean Society of New York, No. 31, [for] 1918–1919 [December 23, 1919], pp. 23–56, pls. I–VII. This paper describes the methods and results of the systematic trapping and banding of birds at Cleveland, Ohio, and Thomasville, Georgia. (Reprinted in No. 19.)

CONTRIBUTION No. 2.—BALDWIN, S. PRENTISS. **Recent Returns from Trapping and Banding Birds.** The Auk, Vol. XXXVIII, No. 2, April, 1921, pp. 228–237. A report of bird banding at Thomasville, Georgia, and Cleveland, Ohio, during 1919 and 1920.

CONTRIBUTION No. 3.—BALDWIN, S. PRENTISS. **The Marriage Relations of the House Wren.** The Auk, Vol. XXXVIII, No. 2, April, 1921, pp. 237–244. Mating habits and genealogy, as learned from banded birds, are here discussed. (Reprinted in No. 19.)

CONTRIBUTION No. 4.—BALDWIN, S. PRENTISS. **Adventures in Bird Banding in 1921.** The Auk, Vol. XXXIX, No. 2, April, 1922, pp. 210–224, pls. VIII–IX. Bird banding results in 1921 at Thomasville, Georgia, and Cleveland, Ohio, are here given.

CONTRIBUTION No. 5.—TALBOT, LESTER R. **Bird Banding at Thomasville, Georgia, in 1922.** The Auk, Vol. XXXIX, No. 3, July, 1922, pp. 334–350, pls. XV–XVII. Report of

Mr. Talbot, who operated the Thomasville bird banding station for Mr. Baldwin in February and March, 1922.

CONTRIBUTION No. 6.—MUSSELMAN, THOMAS E. **Bird Banding at Thomasville, Georgia, 1923.** The Auk, Vol. XL, No. 3, July, 1923, pp. 442–452, pls. XXV–XXVII. Report of Mr. Musselman, who operated the Thomasville bird banding station with Mr. Baldwin in February and March, 1923.

CONTRIBUTION No. 7.—MAY, JOHN B. **Bird Banding at Thomasville, Georgia, 1924.** The Auk, Vol. XLI, No. 3, July 1924, pp. 451–462, pls. XXVII–XXVIII. Report of Doctor May, who operated the Thomasville bird banding station with Mr. Baldwin from January to April, 1924.

CONTRIBUTION No. 8.—BALDWIN, S. PRENTISS. **Bird Banding; Are Birds Frightened or Injured?** The Wilson Bulletin, Vol. XXXVI, No. 2, June, 1924, pp. 101–104.

CONTRIBUTION No. 9.—BALDWIN, S. PRENTISS. **History of the Quail Investigation.** The Wilson Bulletin, Vol. XXXVII, No. 2, June, 1925, pp. 98–100.

CONTRIBUTION No. 10.—BALDWIN, S. PRENTISS; AND KENDEIGH, S. CHARLES. **Attentiveness and Inattentiveness in the Nesting Behavior of the House Wren.** The Auk, Vol. XLIV, No. 2, April, 1927, pp. 206–216, pls. X–XIII. Explains the use of potentiometer and thermocouple in keeping record of nest temperature and movements of female house wren during incubation.

CONTRIBUTION No. 11.—BOULTON, RUDYERD. **Ptilosis of the House Wren.** The Auk, Vol. XLIV, No. 3, July, 1927, 387–414, figs. 1–12. Prepared while Mr. Boulton was acting as assistant at the Baldwin Bird Research Laboratory during the summer of 1926.

CONTRIBUTION No. 12.—MUSSELMAN, THOMAS E. **Foot Disease of Chipping Sparrow (Spizella passerina).** The Auk, Vol. XLV, No. 2, April, 1928, pp. 137–147, pl. VII. A study of bird pox, especially as it appears at Thomasville, Georgia.

CONTRIBUTION No. 13.—BALDWIN, S. PRENTISS; AND BOWEN, W. WEDGWOOD. **Nesting and Local Distribution of the House Wren.** The Auk, Vol. XLV, No. 2, April, 1928, pp. 186–199, figs. 1–5. This paper describes the plan and purposes of the "outfield" work on the house wren at the Baldwin Bird Research Laboratory in 1927.

CONTRIBUTION No. 14.—KENDEIGH, S. CHARLES; AND BALDWIN, S. PRENTISS. **Development of Temperature Control in Nestling House Wrens.** American Naturalist, Vol. LXII, No. 680, May–June, 1928, pp. 249–278. A study of body temperature and methods of taking body temperature of birds.

CONTRIBUTION No. 15.—LINCOLN, FREDERICK C. **Bibliography of Bird Banding in America.** The Auk, Vol. XLV, No. 4, Supplement, October, 1928, pp. 1–73. Although this paper was not prepared by a member of the staff of the Baldwin Bird Research Laboratory, it was written at the request of Mr. Baldwin, by Mr. Lincoln, of the United States Biological Survey, by permission of the Biological Survey.

CONTRIBUTION No. 16.—BALDWIN, S. PRENTISS. **A Bird Research Laboratory.** Bulletin of the Northeastern Bird Banding Association, Vol. IV, No. 4, October, 1928, pp. 115–120. A description of the organization and purposes of the Baldwin Bird Research Laboratory.

CONTRIBUTION No. 17.—BALDWIN, S. PRENTISS; OBERHOLSER, HARRY C.; AND WORLEY, LEONARD G. **Measurements of Birds.** Scientific Publications of the Cleveland Museum of Natural History, Vol. II, October 14, 1931, pp. I–IX, 1–165; figs. 1–151. A manual of external measurements of birds, for use in biological, systematic, and other studies of variation in the size of birds.

CONTRIBUTION No. 18.—KENDEIGH, S. CHARLES; AND BALDWIN, S. PRENTISS. **The Mechanical Recording of the Nesting Activities of Birds.** The Auk, Vol. XLVII, No. 4, October, 1930, pp. 471–480; pls. XV–XVIII; figs. 1–4. A description of the construction and operation of instruments in use at the Baldwin Bird Research Laboratory.

CONTRIBUTION No. 19.—BALDWIN, S. PRENTISS. **Bird Banding by Systematic Trapping.** Scientific Publications of the Cleveland Museum of Natural History, Vol. I, No. 5, April 15, 1931, pp. 125–168; pls. XIX–XXV. A reprint, with corrections, of contributions from the Baldwin Bird Research Laboratory, No. 1, "Bird Banding by Means of Systematic Trapping" and No. 3, "The Marriage Relations of the House Wren."

CONTRIBUTION No. 20.—BALDWIN, S. PRENTISS. **"Bird Sanctuary" Suggestions.** Ohio Journal of Science, Vol. XXXI, No. 3, May, 1931, pp. 172–176. Suggestions for the establishment and maintenance of sanctuaries for birds, in parks, estates, cemeteries, and golf grounds.

CONTRIBUTION No. 21.—BALDWIN, S. PRENTISS; AND KENDEIGH, S. CHARLES. **Physiology of the Temperature of Birds.** Scientific Publications of the Cleveland Museum of Natural History, Vol. III, October 15, 1932, pp. 1–196; pls. Frontispiece, I–V; figs. 1–41. A study of the temperature of passeriform birds, adults, nestlings, and eggs.

CONTRIBUTION No. 22.—PATTEN, BRADLEY MERRILL AND KRAMER, THEODORE C. **A Moving-picture Apparatus for Microscopic Work.** Anatomical Record, Vol. LII, No. 2, March 25, 1932, pp. 169–189. Description of an apparatus for taking motion pictures of microscopic living objects.

CONTRIBUTION No. 23.—KENDEIGH, S. CHARLES. **A Study of Merriam's Temperature Laws.** Wilson Bulletin, Vol. XLIV, No. 3, September 21, 1932, pp. 129–143. A critical examination of the conclusions reached by Dr. C. Hart Merriam in his studies of the laws governing temperature control of the distribution of animals and plants.

CONTRIBUTION No. 24.—BALDWIN, S. PRENTISS; KENDEIGH, S. CHARLES; AND FRANKS, ROSCOE W. **Protect Hawks and Owls in Ohio.** The Ohio Journal of Science, Vol. XXXII, No. 5, September, 1932. Arguments for the protection of all species of hawks and owls.

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SCIENTIFIC PUBLICATIONS
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DESCRIPTIONS OF NEW BIRDS FROM OREGON, CHIEFLY FROM THE WARNER VALLEY REGION

BY
HARRY C. OBERHOLSER

One of the significant developments of ornithology in western North America has been the discovery and exposition of the centers of subspecific differentiation. Such centers are represented by the Victoria Mountains of southern Lower California, the San Pedro Martir Mountains of northern Lower California, the White Mountains of central eastern California, the Charleston Mountains of southwestern Nevada, the Puget Sound region of western Washington, and other localities.

A recent ornithological investigation of the region including the Warner Valley and Warner Mountains of central southern Oregon has shown that this is another such area, and one of unusual importance. Mr. Alex Walker spent several months here in the summer of 1930, collecting birds for the Cleveland Museum of Natural History, an expedition made possible by the generous interest of Mrs. Dudley S. Blossom of Cleveland.

The birds described in the following pages have in most cases their center of distribution in this area, and although some of them have a rather wide range in the western United States, and one occurs only on the Pacific slope, most of them are either confined to the Warner Valley or Warner Mountains or have a somewhat limited distribution north and south of this region. Practically all of them are represented by good series of specimens.

Measurements are taken as described by Baldwin, Oberholser, and Worley, in 'Measurements of Birds,' published as Volume II of the Scientific Publications of the Cleveland Museum of Natural History, Oct. 14, 1931.

Thanks are due Mr. Stanley G. Jewett and Mr. Ludlow Griscom for the loan of comparative material.

Lophortyx californica orecta, subsp. nov.

OREGON QUAIL

Subspecific characters.—Similar to *Lophortyx californica californica* [=*vallicola*], from the Sacramento and San Joaquin valleys, California, but larger, averaging darker, and having the back with much more olivaceous suffusion which thus contrasts more strongly with the color of the nape.

Measurements.—*Adult male* (12 specimens, from the Warner Valley region): wing, 109–119 (average, 113.9) mm.; tail, 77–91 (82.6); exposed culmen, 12–13 (12.5); tarsus, 28–31.5 (30.3); middle toe without claw, 25.5–28 (26.8). *Adult female* (4 specimens, from the Warner Valley region): wing, 111.5–117 (113); tail, 67–82 (75.8); exposed culmen, 11–11.3 (11.1); tarsus, 29–30 (29.4); middle toe, 26–27.5 (26.5).

Type.—Adult male, No. 15001, Cleveland Museum of Natural History; mouth of Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; October 17, 1930; Alex Walker, original number, 3593.

Geographic distribution.—Warner Valley region, central southern Oregon.

Remarks.—This interesting new quail is apparently confined to the region of the Warner Valley, where it is undoubtedly native. I am informed by Mr. Stanley G. Jewett that there is no record or evidence that this species has been introduced into this area. Birds from farther west are smaller and otherwise less typical, and were a sufficient series available might be found to belong to *Lophortyx californica californica* [=*vallicola*].[1]

Phalaenoptilus nuttallii nyctophilus, subsp. nov.

OREGON POOR-WILL

Subspecific characters.—Of the same size as *Phalaenoptilus nuttallii nuttallii* from the Rocky Mountains, but in the light phase much paler, brighter, more silvery above; in the dark phase brighter and averaging rather darker and less ochraceous, with more contrast between the light and dark areas, there being thus much more difference between the extremes of the light and dark phases than exists in *Phalaenoptilus nuttallii nuttallii;* white tips of outer rectrices broader, particularly in the female; and the buffy bars on the rectrices averaging less distinct, particularly on the terminal half of the tail.

Measurements.—*Adult male* (11 specimens, from Oregon, California, and Nevada): wing, 139–146 (average, 143.1) mm.; tail, 78.5–91 (85.9); exposed culmen, 10–12.5 (11.1); tarsus, 17–20 (18.5); middle toe without claw, 15–17 (16.3); white tip of outermost tail-feather, 16–21 (17.6). *Adult female* (11 specimens, from Oregon, California, and Nevada): wing, 137–151.5 (142.3); tail, 82–93 (86); exposed culmen, 9–12 (10.5); tarsus, 17–20 (18.6); middle toe without claw, 15–17.5 (16.5); white tip of outermost tail-feather, 11–14.5 (12.8).

Type.—Adult female, No. 15002, Cleveland Museum of Natural History; Hart Mountain, near site of old Fort Warner, northern end of Warner Valley, 20 miles northeast of Adel, Oregon; August 9, 1930; Alex Walker, original number, 3030.

Geographic distribution.—Breeds in Oregon, Nevada, and the adjoining eastern

[1]For this change of subspecific name, *cf.* Grinnell, Condor, Vol. XXXIII, No. 1, Jan., 1931, pp. 37–38.

edge of California east of the Sierra Nevada, and south to the Death Valley region. Winter range unknown.

Remarks.—This is a race of bright and contrasting colors above, and interestingly with great difference between the light and dark phases. The width of the white tip of the outermost tail-feather in *Phalaenoptilus nuttallii nuttallii* is as follows: male, 13–19 (16); female, 9.5–12.8 (10.8). This new subspecies appears to be most typical in the Warner Valley region. Birds from the southern part of its range, as above given, seem to incline a little toward *Phalaenoptilus nuttallii hueyi* of the lower Colorado Valley. Walker obtained 9 specimens of this new bird in the Warner Valley region.

Empidonax traillii adastus, subsp. nov.

MOUNTAIN FLYCATCHER

Subspecific characters.—Similar to *Empidonax traillii brewsteri*, but with upper parts more grayish or greenish (less yellowish or rufescent) brown.

Measurements.—*Adult male* (10 specimens from Idaho and Oregon): wing, 69.5–73.8 (average, 71.8) mm.; tail, 59–62 (60.6); exposed culmen, 11–12.8 (12.1); tarsus, 17–18 (17.4). *Adult female* (10 specimens from Idaho): wing, 65.3–72 (67.8); tail, 55.5–61 (58.2); exposed culmen, 11.3–12.8 (12.1); tarsus, 16–18 (17).

Type.—Adult male, No. 15003, Cleveland Museum of Natural History; Hart Mountain, northern end of Warner Valley, 20 miles northeast of Adel, Oregon; June 13, 1930; Alex Walker, original number, 2566.

Geographic distribution.—Breeds in the northwestern United States, north to Idaho and eastern Washington; west to central Washington and central eastern California; south to central eastern California, northern Nevada and central Colorado; and east to Wyoming and western Montana. Migrates through Michoacan, Guerrero, and Morelos in Mexico; and winters from Nicaragua southeastward perhaps to northern South America.

Remarks.—This very interesting form of the Traill flycatcher differs from *Empidonax traillii traillii* in its paler, more brownish upper parts and larger bill, in the latter character agreeing with *Empidonax traillii brewsteri*. There has been available a large series of this new form from Oregon, Idaho, and Wyoming. As a definite geographic race, it carries to the extreme the gray-brown phase of the species. Birds from northern Utah, central Colorado, and central eastern California are intermediate, but are nearer this race than to *Empidonax traillii brewsteri*. Birds from central and northeastern Nevada are, however, to be referred to the latter race. All the names that have been bestowed on this species pertain to the recognized forms, so that the present subspecies has hitherto remained unchristened.

Tyrannus tyrannus hespericola, subsp. nov.

WESTERN KINGBIRD

Subspecific characters.—Similar to *Tyrannus tyrannus tyrannus* from the eastern United States, but wing, tail, and tarsus, longer; white tip of tail broader; and upper surface with less of black or slate mixture, thus more uniform, and rather lighter.

Measurements.—*Adult male* (10 specimens from Oregon and Idaho): wing, 118–127 (average, 121.6) mm.; tail, 81–91 (87.6); exposed culmen, 15–18.5 (16.6); tarsus,

20–22.5 (21.1); middle toe without claw, 12–13.5 (13); width of white tip of middle tail-feather, 10–14.5 (12.1). *Adult female* (5 specimens, from Oregon and Idaho): wing, 111–119.5 (114.6); tail, 78–82 (80.4); exposed culmen, 15–17 (16.3); tarsus, 20–22 (21.3); middle toe without claw, 12–14 (12.6); width of white tip of middle tail-feather, 11–13 (12.2).

Type.—Adult male, No. 15004, Cleveland Museum of Natural History; mouth of Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; May 21, 1930; Alex Walker, original number, 2378.

Geographic distribution.—Breeds north to central Manitoba, southern Mackenzie, and southern British Columbia; west to central Oregon; south to central Nevada and northern New Mexico; and east to New Mexico and North Dakota. Winters in southern Mexico and probably also to South America.

Remarks.—The difference in size between this western race and the eastern bird is shown in the following comparative average measurements of eastern males: wing, 118; tail, 83.6; exposed culmen, 16.4; tarsus, 18.2; middle toe without claw, 14.1; width of white tip of middle rectrix, 9.1. All the specific and subspecific names applied to this species were based on the bird from eastern North America, leaving the present form without a subspecific designation.

Otocoris alpestris lamprochroma, subsp. nov.

OREGON HORNED LARK

Subspecific characters.—Similar to *Otocoris alpestris merrilli*, but with upper parts paler, the brown areas more grayish (less rufescent); in winter plumage also paler, more grayish above, and less extensively suffused with yellow on anterior lower parts.

Measurements.—Adult male (15 specimens, from central southern Oregon): wing, 101–106 (average, 102.6) mm.; tail, 61–69 (66.5); exposed culmen, 10.5–12.5 (11.6); tarsus, 20–23 (21.6); middle toe without claw, 10–12 (11.3). *Adult female* (10 specimens, from central southern Oregon): wing, 92–98 (94.8); tail, 56–62.5 (58.6); exposed culmen, 10–12.5 (11.3); tarsus, 18.5–22 (20.6), middle toe without claw, 10–12 (10.8).

Type.—Adult male, No. 15005, Cleveland Museum of Natural History; Spanish Lake, east base of Hart Mountain, northern end of Warner Valley, 20 miles northeast of Adel, Oregon; June 12, 1930; Alex Walker, original number, 2557.

Geographic distribution.—Breeds in the Warner Valley region of central southern Oregon, north to the mouth of the Deschutes River in the central northern part of the state; and south to the Carson Valley, central western Nevada. Casual in spring east to Harney County, Oregon. Winter home unknown, but probably in Nevada or Arizona.

Remarks.—This interesting new form is similar to *Otocoris alpestris praticola*, but is smaller, paler above, and more extensively yellow on anterior lower parts, forehead, and superciliary stripe, particularly in winter. It resembles *Otocoris alpestris leucolaema*, but is smaller, with upper parts posterior to nape darker, more blackish, and more grayish (less ochraceous); nape and rump more pinkish (less ochraceous) cinnamon. Birds from the Warner Valley are most typical. Those from farther north in Oregon, as far as the mouth of the Deschutes River, verge

somewhat toward *Otocoris alpestris merrilli*. Birds from Quincy, California, are also to be referred here, although inclining toward *Otocoris alpestris sierrae*. Specimens from the vicinity of Carson, and of Pyramid Lake, Nevada, which have sometimes been referred to the eastern *Otocoris alpestris praticola*, are really nearer this new race, although, of course, somewhat intermediate between it and the geographically adjoining forms, *Otocoris alpestris leucolaema* and *Otocoris alpestris sierrae*. Of this new race about 70 adults in breeding plumage and about 50 in winter dress have been available for examination.

Stelgidopteryx ruficollis aphractus, subsp. nov.

WESTERN ROUGH-WINGED SWALLOW

Subspecific characters.—Similar to *Stelgidopteryx ruficollis serripennis*, but averaging somewhat larger; lower parts paler, the middle of the abdomen more clearly white (less tinged with grayish); and upper parts averaging darker, more sooty (less rufescent).

Measurements.—*Adult male* (17 specimens, from Oregon, Idaho, California, and Wyoming): wing, 108–115 (average, 111.4) mm.; tail, 48–52 (50.2); exposed culmen, 5.5–7 (6.3); tarsus, 11–12.5 (11.7); middle toe without claw, 9–10.5 (9.6). *Adult female* (10 specimens, from Oregon, Idaho, and Washington): wing, 100.5–110 (105.2); tail, 45.5–50 (48); exposed culmen, 6.3–7 (6.6); tarsus, 11–12.5 (11.9); middle toe without claw, 9.3–10 (9.6).

Type.—Adult female, No. 15006, Cleveland Museum of Natural History; Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; April 23, 1930; Alex Walker, original number, 2151.

Geographic distribution.—Breeds in the northwestern United States, north to Washington; west to central Washington and central Oregon; south to California, Colorado, also probably to northern Arizona and northern New Mexico; and east to the Rocky Mountains in Colorado and Montana.

Remarks.—Differences that separate this subspecies from the eastern race are easily appreciated in a series. From *Stelgidopteryx ruficollis psammochrous*[2] it differs in its darker upper parts and rather darker anterior lower surface. Specimens from the Rocky Mountain region are a little darker below than those from the Warner Valley in Oregon, but are decidedly nearer this new race than to the typical eastern bird. Birds from southern Arizona, north to Fort Verde in central Arizona, are somewhat intermediate between the Oregon bird and *Stelgidopteryx ruficollis psammochrous*, but are nearer the latter. The range of *Stelgidopteryx ruficollis psammochrous* should, therefore, be extended into the United States as far as central Arizona, westward to Lower California, and southward in Mexico to Jalisco, Sinaloa, and Nayarit; also, in winter at least, to Michoacan.

Breeding birds from the State of Vera Cruz are, however, *Stelgidopteryx ruficollis fulvipennis* (Sclater),[3] as has already been shown by Bangs.[4] This, therefore, is

[2]Griscom, Proc. New England Zoöl. Club, Vol. XI, Dec. 14, 1929, p. 72 ("Oposura, Sonora, Mexico").

[3]*Cotyle fulvipennis* Sclater, Proc. Zool. Soc. Lond., Vol. XXVII, 1859 [April 1, 1860], p. 364 ("vicinity of Jalapa in the State of Vera Cruz" [Mexico]).

[4]Proc. New England Zoöl. Club, Vol. II, July 31, 1901, p. 59.

the same as *Stelgidopteryx salvini* Ridgway,[5] since Griscom has shown[6] that this latter is the breeding bird of the same region, and consequently *Stelgidopteryx salvini* becomes a synonym of *Stelgidopteryx ruficollis fulvipennis*.

Petrochelidon albifrons aprophata, subsp. nov.

OREGON CLIFF SWALLOW

Subspecific characters.—Similar to *Petrochelidon albifrons hypopolia* from Mackenzie and Alaska, but lower parts paler, and forehead more buffy (less clearly whitish).

Measurements.—*Adult male* (7 specimens from Adel, Oregon): wing, 109–113.3 (average, 111.2) mm.; tail, 49–52.5 (50.2); exposed culmen, 7–8 (7.3); tarsus, 12.3–14 (13.2); middle toe without claw, 11–12.8 (12). *Adult female* (3 specimens from Adel, Oregon): wing, 108–112 (109.8); tail, 48.5–50 (49.3); exposed culmen, 7–8 (7.5); tarsus, 12–14 (13); middle toe without claw, 10.8–12.5 (11.8).

Type.—Adult male, No 15007, Cleveland Museum of Natural History; mouth of Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; June 19, 1930; Alex Walker, original number, 2611.

Geographic distribution.—Breeds in the Warner Valley region of central southern Oregon. Winter range unknown, but probably South America.

Remarks.—The breeding cliff swallows of this new race from the Warner Valley are large and gray below, differing in this respect from the more eastern forms, and are nearest to the Canadian subspecies, *Petrochelidon albifrons hypopolia*.

Cyanocitta stelleri syncolla, subsp. nov.

WARNER JAY

Subspecific characters.—Similar to *Cyanocitta stelleri frontalis*, but decidedly larger; and somewhat darker, both above and below.

Measurements.—*Adult male* (2 specimens from Oregon): wing, 152–152.5 (average, 152.3) mm.; tail, 140–145 (142.3); exposed culmen, 27–29 (28); tarsus, 43–44 (43.5); middle toe without claw, 23.5–25 (24.3). *Adult female* (4 specimens from Oregon and northeastern California): wing, 142.5–148 (144.6); tail, 130–138 (132.7); exposed culmen, 23–27 (25.7); tarsus, 40–42.5 (41.1); middle toe without claw, 24–26 (25).

Type.—Adult female, No. 15017, Cleveland Museum of Natural History; Barley Camp, Warner Mountains, 14 miles southwest of Adel, Oregon, altitude 6400 feet, July 10, 1930; Alex Walker, original number, 2794.

Geographic distribution.—Central southern Oregon and northeastern California.

Remarks.—The bird inhabiting the Warner Mountains is apparently the extreme development in a northeastern direction of *Cyanocitta stelleri frontalis* of the Sierra Nevada in California. It differs from *Cyanocitta stelleri carbonacea* in its larger size and much paler upper and lower parts, and from the bird of the coast areas of Oregon and Washington in its much paler upper and lower parts. Birds from the Warner Mountains are most typical, yet examples from Lakeview, Oregon, and from Aden, northeastern California, though darker and verging somewhat toward

[5] Bull. U. S. Nat. Mus., No. 50, Part III, Dec. 31, 1904, p. 62 ("Dueñas, Guatemala").

[6] Proc. New England Zoöl. Club, Vol. XI, Dec. 14, 1929, pp. 70–71.

the bird of the Oregon coast area, are of the same size as *Cyanocitta stelleri syncolla*, and are better referred to this form.

Cyanocitta stelleri paralia, subsp. nov.

EVERGREEN JAY

Subspecific characters.—Similar to *Cyanocitta stelleri stelleri* from Alaska and Vancouver Island, but smaller; of a lighter, more greenish blue on both upper and lower parts; light blue streaks on the forehead more conspicuous; back more washed with bluish.

Measurements.—Adult male (10 specimens from Oregon): wing, 139.5–151.5 (average, 143.9) mm.; tail, 130–143 (134.6); exposed culmen, 27.3–31 (28.7); tarsus, 42–46 (43.9); middle toe without claw, 24–26 (25). *Adult female* (10 specimens from Oregon): wing, 136.5–147 (140.6); tail, 121.5–138 (130); exposed culmen, 27–29.5 (28.1); tarsus, 41–46 (43.3); middle toe without claw, 23–26 (24.8).

Type.—Adult male, No. 15018, Cleveland Museum of Natural History; Pleasant Valley, 9 miles southeast of Tillamook, Oregon; January 14, 1930; Alex Walker, original number, 1428.

Geographic distribution.—Western Oregon and western Washington, north to the mainland of southwestern British Columbia, exclusive of Vancouver Island; and east to the Cascade Mountains.

Remarks.—This new race differs from *Cyanocitta stelleri carbonacea* in its larger size; more blackish, though darker, back; less greenish tone of the blue, both above and below; and in having the light bluish streaks on the forehead less conspicuous. The coastal birds of Oregon and Washington are so different, as above indicated, from both *Cyanocitta stelleri stelleri* and *Cyanocitta stelleri carbonacea* that they are best regarded as a separate subspecies as are so many other forms inhabiting the same area. In fact, these birds have sometimes been referred to one, sometimes to the other of the races mentioned above. Birds from the southwestern corner of the mainland of British Columbia, such as those from Agassiz and Lund, verge somewhat toward *Cyanocitta stelleri stelleri*, but are nearer the present form. Birds from Vancouver Island (the type locality of *Cyanocitta stelleri*) are, on the other hand, apparently identical with birds from southeastern Alaska.

Baeolophus inornatus zaleptus, subsp. nov.

WARNER VALLEY TITMOUSE

Subspecific characters.—Similar to *Baeolophus inornatus griseus*, but much more clearly grayish above with practically none of the brownish tinge so evident in the latter race; also paler above; and somewhat lighter, more clearly grayish below, with little or no buffy wash.

Measurements.—Adult male (1 specimen from Adel, Oregon): wing, 73 mm.; tail, 59.8; exposed culmen, 11; tarsus, 20.5; middle toe without claw, 12. *Adult female* (1 specimen from Adel, Oregon): wing, 71.8; tail, 61; exposed culmen, 12; tarsus, 21; middle toe without claw, 12.

Type.—Adult female, No. 15008, Cleveland Museum of Natural History; rim of Warner Valley northwest of the Jacobs Ranch, Twenty Mile Creek, 9 miles south of Adel, Oregon; May 3, 1930; Alex Walker, original number, 2231.

Geographic distribution.—Resident in the Warner Valley region of central southern Oregon.

Remarks.—This very interesting new race is most like *Baeolophus inornatus griseus*, but very different from *Baeolophus inornatus sequestratus* Grinnell in its larger size and much paler, more grayish coloration.

Thryomanes bewickii atrestus, subsp. nov.

WARNER VALLEY WREN

Subspecific characters.—Similar to *Thryomanes bewickii drymoecus* from the San Joaquin Valley, California, but much less rufescent (more grayish) above; somewhat darker; and averaging larger.

Measurements.—Adult male (10 specimens, from southern Oregon): wing, 52.5–55 (average, 53.8) mm.; tail, 50.5–55.5 (52.7); exposed culmen, 14–14.8 (14.3); tarsus, 18.5–20 (19.1); middle toe without claw, 11.5–12.5 (12.1). *Adult female* (5 specimens, from southern Oregon): wing, 49.5–51.5 (50.4); tail, 45–53.5 (49.7; exposed culmen, 12.5–13.5 (13); tarsus, 18–19.5 (18.7); middle toe without claw, 11–12 (11.6).

Type.—Adult male, No. 15009, Cleveland Museum of Natural History; mouth of Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; October 17, 1930; Alex Walker, original number, 3595.

Geographic distribution.—Resident in central southern Oregon, from the Warner Valley west to Medford and Ashland, and north to Gold Hill.

Remarks.—This new race is most typical in the Warner Valley. Birds from localities west to Gold Hill, Ashland, Keno, and Klamath Falls are somewhat rufescent above, thus inclining a little toward the race occupying the coast of Oregon. Compared with *Thryomanes bewickii calophonus* the present form is so much smaller and more grayish that it needs no special comparison. Altogether a series of 20 examples has been available.

Hylocichla guttata oromela, subsp. nov.

CASCADE HERMIT THRUSH

Subspecific characters.—Of the same size as *Hylocichla guttata guttata* from southern Alaska, but with upper parts decidedly paler and more grayish or greenish (less brownish or rufescent).

Measurements.—Adult male (8 specimens from Oregon, California, and Washington): wing, 87–92.5 (average, 88.9) mm.; tail, 64.5–70.5 (66.7); exposed culmen, 12–13.5 (12.7); tarsus, 28–30 (28.9); middle toe without claw, 15–17 (15.6). *Adult female* (10 specimens from Washington): wing, 82.3–89.8 (84.7); tail, 62–67.5 (64.2); exposed culmen, 12.5–14 (13.2); tarsus, 26–29 (27.8); middle toe without claw, 15.5–17 (16.1).

Type.—Male, No. 15010, Cleveland Museum of Natural History; north base of Crook Peak, Warner Mountains, 15 miles northeast of Lakeview, Oregon; August 28, 1930; Alex Walker, original number, 3187.

Geographic distribution.—Breeds from central northern California, north through central and western Oregon, and central and western Washington, to central southern British Columbia. Winters south to southern Lower California (Mount

Miraflores), southeastern California (Panamint Mountains), southwestern California (Petaluma), Chihuahua (Colonia Garcia), central Texas, and central Nuevo Leon (Linares). Of casual occurrence, at least in migration, in New Mexico (Chusca Mountains, October 10, 1908), and also west to southwestern British Columbia (Vancouver). Accidental in Ohio.

Remarks.—It is similar to *Hylocichla guttata sequoiensis*, but is smaller and more grayish. It somewhat resembles *Hylocichla guttata slevini*, but is larger and more grayish as well as somewhat darker. Birds from central northern California incline toward *Hylocichla guttata sequoiensis*, but are probably better referred to the present form. As in many of the races of this species there are two color phases of plumage, gray and rufescent; and comparisons, therefore, need, of course, to be made with specimens of the proper phase. In its rufescent phase it is not nearly so rufescent as is *Hylocichla guttata guttata*. Apparently none of the names that have been applied to the hermit thrushes refer to this bird.

Vireosylva gilva leucopolia, subsp. nov.

OREGON WARBLING VIREO

Subspecific characters.—Similar to *Vireosylva gilva swainsonii*, and of the same size, but with the upper parts paler, more clearly grayish, and with less tinge of olivaceous, particularly on the back; lower parts rather paler, more clearly white.

Measurements.—Adult male (7 specimens from Adel, Oregon): wing, 65.5–69 (average, 67.1) mm.; tail, 46.5–51.5 (49.1); exposed culmen, 9.5–10.3 (10); tarsus, 17–18.5 (17.7); middle toe without claw, 9–9.8 (9.5). *Adult female* (5 specimens from Oregon): wing, 65.5–70 (67.2); tail, 47.5–52.5 (49.2); exposed culmen, 10; tarsus, 17.5–18 (17.9); middle toe without claw, 9.8–11 (10.4).

Type.—Adult male, No. 15011, Cleveland Museum of Natural History; Barley Camp, Warner Mountains, 14 miles southwest of Adel, Oregon, altitude 6400 feet; July 15, 1930; Alex Walker, original number, 2840.

Geographic distribution.—Breeds in the Warner Valley region of central southern Oregon, north to central Oregon; and south to central western Nevada. Migrates through southeastern California (Laguna Dam), southwestern Arizona (Yuma), and central Arizona (Mayer); and winters probably in Mexico.

Remarks.—This interesting new subspecies appears to be confined in the breeding season in the Warner Valley and to a narrow area north and south of this region, as birds to the east and to the west belong to other races.

Euphagus cyanocephalus aliastus, subsp. nov.

WESTERN BREWER BLACKBIRD

Subspecific characters.—Similar in size to *Euphagus cyanocephalus cyanocephalus* from the Rocky Mountain region, but female darker, particularly below, and usually less rufescent (more grayish); male with posterior lower surface more bluish (less yellowish) metallic green.

Measurements.—Adult male (10 specimens from Oregon): wing, 126.5–133 (average, 130) mm.; tail, 95.5–104.5 (100); exposed culmen, 18–20.8 (19.4); tarsus, 30–34 (32.2); middle toe without claw, 20.5–23 (22.2). *Adult female* (10 specimens

from Oregon): wing, 115–122 (117.5); tail, 87–93 (89.8); exposed culmen, 17–19 (17.8); tarsus, 30–31.8 (30.5); middle toe without claw, 19.8–22 (20.8).

Type.—Adult female, No. 15012, Cleveland Museum of Natural History; Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; May 2, 1930; Alex Walker, original number, 2230.

Geographic distribution.—Breeds in the Pacific coast region from central British Columbia to northern California. Winters from southern British Columbia and southern Idaho to southern Arizona.

Remarks.—Males of this species are apparently not, in size, distinguishable from the typical *Euphagus cyanocephalus cyanocephalus*, but the posterior lower parts average more bluish (less yellowish) metallic green. Juvenal specimens of *Euphagus cyanocephalus aliastus* are even more different from the same age of the typical race than are adults, being much darker above and below and decidedly less rufescent.

Since the original description of *Euphagus cyanocephalus*[7] was based on a male bird from Mexico, which at the time of the original description probably came from central or southeastern Mexico; and since now there is no definite means of identifying the subspecies, it seems wisest to fix as the typical race the bird breeding in the Rocky Mountain region and wintering in Mexico. None of the other names applied to this species refer to the Oregon race.

Oberholseria chlorura zapolia, subsp. nov.

OREGON GREEN-TAILED TOWHEE

Subspecific characters.—Similar to *Oberholseria chlorura chlorura* from the Rocky Mountains, but upper parts, particularly the back, more grayish (less greenish or brownish); and in winter, if brownish above, this color less rufescent (more grayish), and the olive green less yellowish; flanks more grayish (less extensively and less brightly buffy); anterior lower surface more clearly gray (less buffy), and averaging somewhat darker.

Measurements.—*Adult male* (10 specimens from Oregon and California): wing, 77–81.5 (average, 78.8) mm.; tail, 77–86.5 (80.1); exposed culmen, 11.8–13.5 (12.4); tarsus, 24–27 (25.2); middle toe without claw, 15–17 (15.8). *Adult female* (10 specimens from Oregon and California): wing, 74–78 (75.8); tail, 74.5–83.5 (79.5); exposed culmen, 11–13 (11.7); tarsus, 22–25 (23.8); middle toe without claw, 15–16.8 (15.7).

Type.—Adult male, No. 15013, Cleveland Museum of Natural History; Hart Mountain, northern end of Warner Valley, 20 miles northeast of Adel, Oregon; June 9, 1930; Alex Walker, original number, 2515.

Geographic distribution.—Breeds in the Warner Valley region in central southern Oregon, north to Sisters, central Oregon; south to southwestern Nevada, and southeastern California to the San Jacinto Mountains, including the Lake Tahoe region; east to northeastern Nevada. Casual, at least in migration, to Vail in eastern Oregon. Winters from southwestern California and southern Arizona (Rincon Mountains and Springerville) south to southern Lower California and southern Sonora, and casually east to central western Texas.

[7] *Ps[arocolius]. cyanocephalus* Wagler, Isis von Oken, Band XXII, Heft 7, July, 1829, col. 758 ("Mexico." We here designate the Valley of Mexico as the typical locality).

Remarks.—Birds of this species from all of the Rocky Mountain region are apparently identical and represent the typical race. The type of *Oberholseria chlorura*, which was collected by J. K. Townsend in the Rocky Mountain region of southern Idaho on Ross Creek, 20 miles southwest of Blackfoot, has been examined in the present connection, and agrees, of course, with other Rocky Mountain specimens. The bird described by Gambel as *Fringilla blandingiana*[8] is the same as *Oberholseria chlorura chlorura*. The Oregon bird is thus without a name. Specimens from California and Nevada are slightly intermediate, but nearer the present race, which is most typical in the Warner Valley region. Twenty-nine specimens from Oregon have been examined in addition to a series from Nevada.

Pooecetes gramineus definitus, subsp. nov.

GREAT BASIN VESPER SPARROW

Subspecific characters.—Similar to *Pooecetes gramineus confinis* from North Dakota and Montana, but with white area on the inner web of the outer tail-feather much less in linear extent, and absent on the inner web of the second rectrix from the outside (except sometimes for a very narrow tip or whitish edging); upper parts averaging paler; and size slightly greater.

Measurements.—*Adult male* (10 specimens from southern Oregon): wing, 80–86.5 (average, 83.7) mm.; tail, 61–68 (64.2); exposed culmen, 10–11 (10.4); tarsus, 20–22 (21.1); middle toe without claw, 13.5–15 (14.3); length of white on inner web of outer tail-feather, 26.5–42.5 (32.5). *Adult female* (10 specimens from Oregon, California, and Arizona): wing, 75.5–82 (average, 78.6 mm.; tail, 58–65.5 (61.2); exposed culmen, 10–11 (10.6); tarsus, 20–22 (20.9); middle toe without claw, 13.3–14.5 (14); length of white on inner web of outer tail-feather, 26-39 (32.3).

Type.—Adult male, No. 15014, Cleveland Museum of Natural History; Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; May 3, 1930; Alex Walker, original number, 2236.

Geographic distribution.—Breeds in Nevada and central eastern California, north to interior Washington, and east to southeastern Oregon (Harney); winters from southern California and southwestern Arizona (Yuma), south to Chihuahua (Colonia Diaz), Sonora (Alamos), Sinaloa (Culiacan), and the State of Mexico (Tlalpam); casual in migration east to central Texas.

Remarks.—Birds from Idaho are intermediate, but are slightly nearer the Plains race, the breeding range of which is thus the Great Plains and the Rocky Mountain region north to central Canada, west to Idaho and Utah, south to New Mexico and Arizona, and east to North Dakota; and it winters from the southwestern United States south to southern Mexico.

The white area on the inner web of the outer tail-feather in *Pooecetes gramineus confinis* measures 33–61.5 mm. (average, 40.9). The type of the western vesper sparrow[9] came from the Loup Fork of the Platte River in central Nebraska, and is an example of the race breeding on the Great Plains and in the Rocky Mountains, so that the Great Basin race has hitherto been without a name.

[8] Proc. Acad. Nat. Sci. Phila., I, No. 24–25, April, 1843, p. 260 ("Rocky Mountains about half way between New Mexico and Colorado of the west").

[9] *Poocætes gramineus* var. *confinis* Baird, in Baird, Cassin, and Lawrence, Rep. Expl. and Surv. R. R. Pac., Vol. IX, 1858, p. 448.

Chondestes grammacus actitus, subsp. nov.

OREGON LARK SPARROW

Subspecific characters.—Similar to *Chondestes grammacus strigatus* from Mexico, but with the upper parts, excepting the chestnut stripes of the head, decidedly paler; wing somewhat longer.

Measurements.—Adult male (10 specimens from Adel, Oregon): wing, 87.5–95.5 (average, 91.5) mm.; tail, 68–75 (71); exposed culmen, 11.3–12.5 (12); tarsus, 20–22 (20.9); middle toe without claw, 14–17 (15.4).

Type.—Adult male, No. 15015, Cleveland Museum of Natural History; mouth of Twenty Mile Creek, Warner Valley, 9 miles south of Adel, Oregon; May 26 1930; Alex Walker, original number, 2411.

Geographic distribution.—Breeds in the Warner Valley of southern Oregon. In migration, probably also in winter, south to southern Arizona (Redington).

Remarks.—This interesting new form breeds, so far as known, in only central Oregon, and is apparently without a name. The western lark sparrow was originally described[10] from Temiscaltepec in the State of Mexico on the southern part of the Mexican tableland, and the name with little doubt was based on the breeding bird of northern Mexico and southern Arizona, which is of the same size as the measurements given of the type of *Chondestes strigatus*, and which ranges in winter south to Sinaloa, Oaxaca, and Chiapas. We, therefore, now restrict the name *Chondestes strigatus* to this subspecies. A series of 18 specimens from the Warner Valley has been available for the characterization of *Chondestes grammacus actitus*.

Zonotrichia leucophrys oriantha, subsp. nov.

OREGON WHITE-CROWNED SPARROW

Subspecific characters.—Similar to *Zonotrichia leucophrys leucophrys* from northeastern Manitoba, but much paler above, particularly on nape, back, and rump, as well as below on breast and flanks; also more grayish (less brownish) on rump, back, and flanks; and somewhat larger.

Measurements.—*Adult male* (10 specimens from Oregon): wing, 77–82 (average, 79.2) mm.; tail, 71–77.5 (73.7); exposed culmen, 10.5–11.5 (11); tarsus, 23.5–25 (24); middle toe without claw, 16–17.5 (16.8). *Adult female* (10 specimens from Oregon): wing, 71.5–77 (74.4); tail, 67–73 (70.2); exposed culmen, 10.8–11.8 (11.2); tarsus, 22–24 (22.9); middle toe without claw, 15–17 (16).

Type.—Adult male, No. 15016, Cleveland Museum of Natural History; Barley Camp, Warner Mountains, 14 miles southwest of Adel, Oregon, altitude 6400 feet; July 8, 1930; Alex Walker, original number, 2771.

Geographic distribution.—Breeds in the Warner Mountains, Oregon, south to central eastern California. Winters from Arizona and southern California, south to Lower California, Chihuahua, and Jalisco, in Mexico. Casual in southern Texas.

Remarks.—This new white-crowned sparrow is of the *leucophrys* type as contrasted with the white-lored species *Zonotrichia gambelii*, which latter seems to be specifically distinct, since its range overlaps that of *Zonotrichia leucophrys*. Thus *Zonotrichia gambelii* breeds south to eastern British Columbia, Montana, and York Factory in Manitoba, in which localities *Zonotrichia leucophrys* also breeds.

[10] *Chondestes strigatus* Swainson, Philos. Mag., n. s., Vol. I, No. 6, June, 1827, p. 435.

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BIRDS OF EASTERN NEWFOUNDLAND

By
JOHN W. ALDRICH
and
DAVID C. NUTT

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BIRDS OF EASTERN NEWFOUNDLAND

BY
JOHN W. ALDRICH
AND
DAVID C. NUTT

INTRODUCTION

Eastern Newfoundland has been explored by only a few ornithologists even up to the present day and little is known about its bird life. Therefore, it was indeed a matter of good fortune that the junior author was enabled to undertake a brief exploration of this region while a member of the Robert A. Bartlett Greenland Expeditions of 1937, 1938, and 1939. A total of 13 days in early July and early September were spent ashore on the Avalon Peninsula, while another 25 days during the 3 years were consumed in cruising along the south and east coasts of Newfoundland on the way to and from Labrador and points north. During this time a record was kept of all birds encountered and, wherever possible, specimens were collected.

The coastal region of eastern Newfoundland is characterized by barren, rocky tundra and low scrubby spruce. Vegetation is scarce except in the hollows where practically all of the soil accumulates. High grassy flats above Brigus are partially covered with a mat of low wiry shrubs, and are bounded on the harbor and seaward sides by rocky cliffs.

Farther inland the bold coastal features blend into a less rugged landscape 200-300 feet above sea level. At Hodge Water, a region of glacial drift, 11 miles inland from Brigus, there is a small chain of lakes surrounded by low rolling hills. The landscape is covered for the most part by a dense second growth of spruce with occasional tamaracks. The forest is broken occasionally by barren or grassy open spaces. Bogs are numerous. Blueberry in the drier situations

and sweet gale in the wetter places form the chief ground cover. Our party collected in this region from July 7 to 9, 1938.

Four days in early September 1938 and 1939 and 2 days in early July 1939 were spent at Makinson's Grove, known also as the Gould. Makinson's Grove is 6 miles inland and the only area in the vicinity of Brigus where any sizable timber occurs. It is almost entirely spruce with a few tamaracks and an occasional stunted maple. All the trees are covered with a scaly lichen and usnea moss is commonly seen festooning the branches.

At Makinson's Grove the comparatively great diversity of habitat makes it better bird country than most other sections visited. There are wet areas covered by low bog shrubs, the home of the swamp sparrow. One section is open, grazed land that blends into a dense forest toward the north. In the bottom of the valley flows a shallow but swift stream.

During the time ashore in Newfoundland an almost continuous high wind made collecting and observing difficult. In July of 1939 it rained the entire time ashore thus further handicapping operations. In the areas visited bird life was abundant, but the number of individual species of land birds seemed to be comparatively restricted. Only 37 species were recorded during the 13 days of observation ashore.

Specimens collected by the junior author, assisted by Raymond Hellmann and Samuel Bartlett number 82 and comprise 20 species. The discovery of 2 previously undescribed subspecies in this comparatively small collection gives some idea of the little known condition of the bird life of this region.

G. K. Noble (1919) in his illuminating paper on geographic variation based on a collection from the western part of the island concludes that Newfoundland is a region where the differentiation of dark colored races is beginning to take place.

The results of our studies confirm this opinion. It would seem that this darkening, noticeable in the west, becomes increasingly more marked in the eastern part of the island. This was found to be the case particularly with the Savannah sparrow, robin, and black-capped chickadee.

The only previous publications dealing definitely with the ornithology of eastern Newfoundland seem to be those of E. A. Brooks

(1936) who spent 9 days in the summer of 1932 studying the birds of the Avalon Peninsula, and K. B. Rooke (1935) who worked chiefly in the Grand Falls region, near the center of the Island, but also obtained some interesting records from the Avalon Peninsula. It is, therefore, a comparatively easy matter to bring the information on the birds of eastern Newfoundland up to date, and at the same time add materially to the knowledge of the distribution, abundance, and geographic variation of a few species found in this interesting part of North America.

We are indebted to Mr. Gower Rabbitts, of the Department of Natural Resources of Newfoundland, for the permits to collect birds there; to Captain Robert A. Bartlett whose kindness and patience made the ornithological work on the Expedition possible; and to Dr. Harry C. Oberholser who has very generously gone over the entire manuscript and favored us with invaluable criticism and advice.

BIRDS KNOWN TO OCCUR IN EASTERN NEWFOUNDLAND

Gavia immer immer (Brünnich). Common Loon.
Local name: Loo.

On the 1938 expedition loons were heard during both nights spent on the chain of lakes at Hodge Water. Brooks (1936) records seeing only one during the nine days of his stay on the Avalon Peninsula, while Rooke (1935) found 1 or more loons on the lakes of the Grand Falls region in the interior of Newfoundland.

Puffinus griseus (Gmelin). Sooty Shearwater.
Local name: Black Hagdown.

Off Bonavista Bay and near the Funk Islands 8 sooty shearwaters were seen on July 12 and 13, 1938. On July 7, 1939, there were a few seen with a large flock of greater shearwaters at the mouth of Conception Bay. In September 1938, none were recorded; but 3 were seen on August 30 and 31, 1939, while coming toward the Newfoundland Coast near Cape Bonavista. It would seem that the sooty shearwater is of irregular occurrence off Eastern Newfoundland.

Puffinus gravis (O'Reilly). GREATER SHEARWATER.
Local name: Hagdown.

The greater shearwater is a common bird off the south and east coast of Newfoundland, especially so on the fishing banks. A fishing schooner is often seen surrounded by a cloud of "Hagdowns". On July 7, 1939, a flock, estimated at over 800, was encountered at the mouth of Conception Bay. These birds are common along the Labrador coast. In early September most of the greater shearwaters appear to have shifted southward and are more common on the Grand Banks and to the westward. However, so irregular is the occurrence of this species that one day thousands are to be seen and the next day none at all.

Fulmarus glacialis glacialis (Linnaeus). ATLANTIC FULMAR.
Local name: Noddy.

Going north the fulmar was first met with off Cape St. Mary's in southern Newfoundland, where two were observed on July 5, 1939. It became increasingly common farther north, particularly off the Funk Islands where a large number were observed on July 13, 1938. In 1939 our party found it uncommon until well out to sea between Newfoundland and southern Greenland. On the return voyages late in the summer fulmars were never close to the shore of eastern Newfoundland.

Practically all fulmars along the Newfoundland coast were of the light phase with only a very few that might be considered as even intermediate between the light and dark plumages.

Oceanodroma leucorhoa leucorhoa (Vieillot). LEACH PETREL.
Local name: Carey chick, or Mother Carey's chick.

The Leach petrel is a common bird off the east coast of Newfoundland, especially about the Funk Islands near which a specimen was collected July 18, 1937, and where the Newfoundland sailors say that it breeds. Lucas (1890) found them breeding at the Penguin Islands 10 miles north-west of Cape Freels in the summer of 1887.

It is interesting to note that on calm days, petrels are rarely observed, whereas on days having a little wind and sea, many are to be seen. It seems to be easier for them to fly in the wind using the up-drafts caused by the waves, as do also the shearwaters. On foggy nights Leach petrels fly close to the vessel and even come aboard.

Moris bassana (Linnaeus). GANNET.

Gannets were often seen off the south and east coasts of Newfoundland and were especially common off Cape St. Mary's, where there is a breeding colony estimated as 4000 pairs in 1934 by Wynne-Edwards (1935). This is the second largest American colony known today according to Gilliard (1937) who discovered another Newfoundland gannet colony on Funk Island. Gilliard states that Jacques Cartier, the discoverer of Funk Island, recorded the gannet as breeding there profusely at the time of his visit in June 1534. Since, however, Lucas (1890) and others failed to find gannets breeding on Funk Island, Gilliard concluded that this species had re-established itself there in comparatively recent times. He found 7 pairs there in June 1936.

Gross (1937) reports that he saw no gannets north of the Straits of Belle Isle while on the Bowdoin-MacMillan Arctic Expedition of 1934. And Austin (1932) says that there is not a single shred of evidence to show that the species has ever occurred north of the Straits of Belle Isle. There is now plenty of evidence to that effect, for on our return voyage in 1938, gannets were recorded 150 miles north of Belle Isle at Bulldog Island (Lat. 54°38′ N., 57°02′ W.) where 3 were seen on August 31. Early in the morning of September 1, the boatswain saw a flock of 10 or 12, and later that day the junior author saw 2 more off Round Hill. From then on down the coast of Labrador and Newfoundland they were fairly common, especially near Cape Broyle where on September 8, 1938, many flocks, including one of 30 and one of 100 birds, were seen. The natives of Square Island, 45 miles north of Belle Isle, Labrador, reported that they had seen numerous gannets during the summer of 1938.

Phalacrocorax (sp.?). CORMORANT.
Local name: Shag.

On August 31, 1937, numerous cormorants were seen in Stag Harbor Run, between Fogo Island and the mainland, but whether the species was *Phalacrocorax auritus* or *P. carbo* could not be determined.

Butorides virescens virescens (Linnaeus). EASTERN GREEN HERON.

A specimen of the green heron from Haricourt, St. Mary's Bay, Avalon Peninsula was given to Rooke for the British Museum by J. R. Ewing of St. John's. However, in the field none were observed by Rooke (1935), Brooks (1936) or our party.

Botaurus lentiginosus (Montagu). AMERICAN BITTERN.

An American bittern was seen at Hodge Water on July 8 and 9, 1938, and another at Makinson's Grove on September 6, 1938.

Ixobrychus exilis exilis (Gmelin). EASTERN LEAST BITTERN.

A specimen of the least bittern from near St. John's, in the possession of Mr. J. R. Ewing, was examined by Rooke (1935).

Branta canadensis canadensis (Linnaeus). COMMON CANADA GOOSE.

Rooke (1935) reports that this species breeds regularly in the interior of eastern Newfoundland where undisturbed. He saw 2 in the Grand Falls region August 15 that acted as if they had young.

Anas rubripes rubripes Brewster. RED-LEGGED BLACK DUCK.

Although unrecorded on our expeditions, Brooks (1936) saw a flock of 6 black ducks flying over a pond at Salmonier on the Avalon Peninsula. From other literature it would appear that this species is, in Newfoundland, more common inland than along the coast.

Glaucionetta clangula americana (Bonaparte). American Golden-eye.

Rooke (1935) saw a few of these ducks in the Grand Falls region in the interior of Newfoundland, but the species is unrecorded by either Brooks (1936) or our party.

Accipiter striatus velox (Wilson). Sharp-shinned Hawk.

One was seen at Makinson's Grove pursuing a flock of Crossbills on September 6, 1938, and again on September 1, of the following year.

Pandion haliaëtus carolinensis (Gmelin). American Osprey.

An osprey was seen by Brooks (1936) on August 5 near Placentia, and this species is reported by Rooke (1935) as not uncommon in the Grand Falls region.

Falco columbarius columbarius Linnaeus. Eastern Pigeon Hawk.

One of these little falcons was seen at "Frog Marsh" near Brigus in September 1937, and the residents say that 1 or 2 individuals are usually to be found there. On September 2, 1938 a flock of eight were seen above the rocky hills near Brigus. Although Brooks (1936) records only 2 pigeon hawks and Rooke (1935) only 1 individual, it would seem that this species is the most common hawk in eastern Newfoundland.

Cerchneis sparveria sparveria (Linnaeus). Eastern Sparrow Hawk.

Rooke (1935) saw a small hawk almost certainly of this species, near St. John's on August 9, 1934.

Lagopus lagopus alleni Stejneger. Allen Ptarmigan.

Lagopus rupestris welchi Brewster. Welch Ptarmigan.
Local name for both species: Pa'tridge.

Brooks (1936) reports seeing specimens of both species of

ptarmigan in the Museum at St. John's and assumes that they were locally taken. He was also told by "competent nature observers" that both species are common in "the Barrens". Most natives do not distinguish between the 2 species but said that "pa'tridges" were common near Brigus. Rooke (1935) quoted fire wardens of the Great Rattling Brook region in the interior of Newfoundland as saying that ptarmigan were numerous in winter there.

Porzana carolina (Linnaeus). Sora.

A specimen from the Avalon Peninsula, given to Rooke (1935) for the British Museum by J. R. Ewing, is the only record from Eastern Newfoundland.

Vanellus vanellus (Linnaeus). Lapwing.

Brewster (1906) records one in Newfoundland in 1906, and Ingersol (1928) records seeing many after a spell of easterly gales in 1927. Although no records are definitely ascribed to eastern Newfoundland, it seems that these wanderers from Europe would perforce first land there.

Capella gallinago delicata (Ord). Wilson Snipe.

This snipe is fairly common in boggy places on the Avalon Peninsula. While our party was camped at Hodge Water in July 1938 one was heard "bleating" overhead at almost all hours of the day and night, as was also the case in July 1939 at Makinson's Grove.

Phaeopus borealis (Forster). Eskimo Curlew.

It is within the memory of many residents of Brigus that on certain fall days "droves" of Eskimo Curlew would come to the high flats above the town, even darkening the sky with their great numbers. There seems to be no record of when they became extirpated there.

Actitis macularia (Linnaeus). Spotted Sandpiper.

Local name: Beachy bird.

Spotted sandpipers are fairly common on the Avalon Peninsula. Brooks (1936) records several. One was seen by our party in

Brigus Harbor July 7, 1938, and on July 6, 1939, a pair was found nesting at Makinson's Grove. The nest was on a dry hillside covered with blueberry bushes about 20 feet above the level of a stream.

Totanus melanoleucus (Gmelin). Greater Yellow-legs.

Local name: Twilick.

This is a common bird in the lake regions of the Avalon Peninsula. Many were seen and heard at Hodge Water where a single specimen was collected July 9, 1938. One was seen in a small pond near Brigus early in September 1937.

Pisobia minutilla (Vieillot). Least Sandpiper.

Local name: Beachy-bird.

One bird, seen at Hodge Water, as far as we know is the only definite record of the least sandpiper for the region. Rooke (1935) states that he saw a small flock of waders on Conception Bay, September 11, which he took to be this species.

Phalaropus fulicarius (Linnaeus). Red Phalarope.

A specimen of the Red Phalarope in breeding plumage in the possession of J. R. Ewing of St. John's was examined and reported by Rooke (1935). It is said to have been taken on Avalon Peninsula. Two were seen by our party on September 4, 1939, out of sight of land, south of St. Mary's Bay.

Lobipes lobatus (Linnaeus). Northern Phalarope.

Local name: Gale bird.

In the early part of September on the return voyages these little phalaropes were fairly common all along the east coast of Newfoundland, especially in the vicinity of Cape Race, where on September 8, 1938, some 200 were seen swimming about in small flocks.

Stercorarius pomarinus (Temminck). POMARINE JAEGER.
Local name: Bosun-bird.

Five Pomarine Jaegers were seen off Cape St. Mary's on July 5, 1938, the only time the species was encountered in Newfoundland waters.

Stercorarius parasiticus (Linnaeus). PARASITIC JAEGER.
Local name: Bosun-bird, Marlin Spike.

On July 12, 1938, off Bonavista Bay, 2 flocks of 20 and 8 birds respectively flew about the vessel for a short time. On August 30, 1939, near the Funk Islands, a flock of 30 stayed in the wake of the vessel for some time and on the following day a few were still present. The Parasitic Jaeger is by no means uncommon off eastern Newfoundland, but it is of decidedly irregular occurrence.

Catharacta skua Brünnich. NORTHERN SKUA.
Local name: Sea hen.

Off Cape Broyle, on July 6, 1938, a number of skuas paid the vessel a visit. A lone bird was observed on August 30, 1939, near the Funk Islands, and again a single individual was seen on September 5 while over St. Pierre Bank. The skua is apparently not common off the coast of eastern Newfoundland, and also is of decidedly irregular occurrence.

Larus hyperboreus hyperboreus Gunnerus. GLAUCOUS GULL.
Local name: Burgomaster, Minister Gull.

A few individuals were seen in Brigus harbor but more near Cape St. Francis on September 3, 1939. On the whole this big gull is not very common on the east coast of Newfoundland.

Larus marinus Linnaeus. GREAT BLACK-BACKED GULL.
Local name: Saddleback.

Only a few black-backs were seen among the gulls in eastern Newfoundland where they are apparently uncommon. A few were seen in Brigus harbor, and a small number near Cape St. Francis.

Larus argentatus smithsonianus Coues. American Herring Gull.

Local name: Sea Gull. Gull.

These gulls were observed commonly off the southeast coast, especially near Cape St. Francis where they appeared to be nesting on the cliffs. A few were always about Brigus harbor, and about a half dozen were observed inland at Hodge Water and Makinson's Grove. Rooke (1935) also found them in the interior on the Exploits River near Grand Falls. Numbers of young herring gulls were seen around Brigus in the fall of 1939.

Rissa tridactyla tridactyla (Linnaeus). Atlantic Kittiwake

Local name: Tickle-else.

Kittiwakes are fairly common, but not known to breed in eastern Newfoundland. On July 7, 1939, 25 of these birds were observed in the mouth of Conception Bay and at almost all other times scattered individuals were in evidence. Hoyes Lloyd (1939) reports that a kittiwake banded in northwestern Russia was taken near Little Fogo Island, Newfoundland, September 20, 1937.

Sterna hirundo hirundo Linnaeus. Common Tern.

Local name: Pietrie.

A few terns were occasionally seen from the vessel along the eastern coast of Newfoundland, but it was usually impossible to determine the species. On September 3, 1938, when near the Funk Islands, and on September 3, 1939, off Bay of Bulls, common terns (2 birds in each case) were positively identified.

Sterna paradisaea Brünnich. Arctic Tern.

Lucas (1890) found Arctic terns breeding in large numbers on Funk Island in 1887. Their young and eggs in an advanced stage of incubation were scattered from one end of the island to the other. Lucas calls attention to the fact that not a single specimen of the common tern was noticed despite the assertion of Stuvitz in 1844 that he was "surprised at the abundance of the Arctic and

common tern" on Funk Island. The difficulty of distinguishing between the common and Arctic tern in the field leaves the status of their comparative abundance in eastern Newfoundland still in doubt.

Plautus impennis (Linnaeus). GREAT AUK.

Lucas (1890) believed that Funk Island 32 miles off the east coast of Newfoundland was the chief breeding ground of the great auk in North America and that the species survived there long after being extirpated in other more accessible localities. Furthermore there seems to be no evidence as yet that the great auk bred at any locality in eastern Newfoundland except Funk Island.

Alca torda Linnaeus. RAZOR-BILLED AUK.

Two were seen on July 8, 1939, near the Funk Islands where Lucas (1890) found them numerous. A few are said to still breed there.

Uria lomvia lomvia (Linnaeus). BRÜNNICH MURRE.

Local name: Baccelieu Bird or Turre.

Murres of this species are not uncommon off the east coast of Newfoundland in summer. At least a few scattered individuals were seen every day in that region. On July 13, 1938, when near the Funk Islands where Lucas (1880) found these murres breeding, and Gilliard (1937) estimated 10,000 breeding pairs, 20 were recorded by our party in a 2-hour period. Many were seen near Cape Spear on July 3, 1939. These murres are said to breed on Baccelieu Island, whence the local name for this species, but there never seemed to be a great number there. The residents say that they are more common in the winter months.

Alle alle (Linnaeus). DOVEKIE.

Local name: Bull-bird or Little Auk.

One was seen swimming near the vessel off Cape Broyle on July 6, 1938, but the species is apparently rare anywhere along the east

coast of Newfoundland in the summer. It is said by the natives to be a common winter resident in Conception Bay.

Cepphus grylle grylle (Linnaeus). Black Guillemot.

Local name: Pigeon, or Sea Pigeon.

Rooke (1935) states that he saw 2 off St. John's. No guillemots were recorded by our party, however, in the 3 years of observation off the eastern coast, despite the fact that a large breeding colony is reported by Wynne-Edwards (1935) at Cape St. Mary's. The natives report it as common in the winter at which time it stays in the open water beyond the harbor ice.

Fratercula arctica arctica (Linnaeus). Atlantic Puffin.

Local name: Sea parrot.

The Puffin is locally common off the eastern coast. It appeared to be breeding near Cape Broyle where great numbers were seen July 6, 1938. Eight individuals were encountered in Trepassy Bay on July 3, 1939, and many were found near Cape Spear later the same day. A few were seen on July 7 at the mouth of Conception Bay. Lucas (1890) found them breeding in great numbers on Funk Island in the summer of 1887. Their burrows were numerous in the thick soil on the top of the island which was formerly the breeding ground of the great auk. The excavated bones of these extinct auks were usually found around the entrances to puffin burrows.

Zenaidura macroura carolinensis (Linnaeus). Eastern Mourning Dove.

According to Lewis (1922) a pair was shot at Trepassy on October 1, 1921, after a severe southerly storm.

Bubo virginianus neochorus Oberholser. Newfoundland Horned Owl.

Several of these large owls were seen and heard by Rooke (1935) in the Grand Falls region where he collected a single specimen. The species is unrecorded by either Brooks (1936) or our party, however.

Nyctea nyctea (Linnaeus). SNOWY OWL.

Rooke (1935) reports 1 seen in the Grand Falls region on August 25, 1934, that he judged to be an early migrant. He states that it is known to occur in Newfoundland as a winter resident.

Megaceryle alcyon alcyon (Linnaeus). EASTERN BELTED KINGFISHER.

Brooks (1936) records several at Bowring Park, St. John's, but none were observed by our party. The natives said that it was very rare near the coast but could be found inland.

Colaptes auratus luteus Bangs. NORTHERN FLICKER.

It would seem that the flicker is the most common woodpecker in eastern Newfoundland. One was heard at Hodge Water on July 8, 1938, and there were always a few to be seen at Makinson's Grove. One nesting pair was observed on July 5, 1939. The nest was found in a sawed off spruce stump 3½ feet above the ground. In it were 6 recently hatched young.

The single female specimen in fresh autumn plumage collected on September 2, 1938, measured as follows: wing, 153.5 mm.; tail, 99.5; culmen, not measurable (broken); tarsus, 28; middle toe without claw, 23.5. The size seems to place the bird as *Colaptes a. luteus* rather than as *C. a. borealis*.

Sphyrapicus varius atrothorax (Lesson). NORTHERN YELLOW-BELLIED SAPSUCKER.

Rooke (1935) obtained a single specimen on Beaver Mountain on August 12, and saw evidence of others in the presence of their workings on birches.

Dryobates villosus terraenovae Batchelder. NEWFOUNDLAND HAIRY WOODPECKER.

Recorded as common by Rooke (1935) in the Grand Falls region, but although the type specimen comes from Placentia on the Avalon

Peninsula, it is seemingly uncommon there. Brooks (1936) saw but 2 at Calinet and our party recorded it only on September 2, 1939, at Makinson's Grove.

Dryobates pubescens microleucus Oberholser. Newfoundland Downy Woodpecker.

This species is apparently rare in eastern Newfoundland since it is entirely unrecorded by either Rooke (1935) or our party, while Brooks (1936) saw but 1 in Bowering Park, St. John's.

Picoïdes tridactylus bacatus Bangs. American Three-toed Woodpecker.

A single specimen taken by Rooke (1935) on Beaver Mountain August 12, 1934, is the only record of this species in eastern Newfoundland.

Empidonax flaviventris (Baird and Baird). Yellow-bellied Flycatcher.

Brooks (1936) saw 1 pair and heard others in eastern Newfoundland and a specimen from the Avalon Peninsula was given to Rooke (1935) by J. R. Ewing of St. John's. The species is apparently uncommon on the Avalon Peninsula since it was not observed by our party.

Nuttallornis borealis cooperi (Nuttall). Eastern Olive-sided Flycatcher.

Rooke (1935) records several for Beaver Mountain August 12, 1934, where a specimen was obtained by him.

Otocoris alpestris alpestris (Linnaeus). Northern Horned Lark.

Local name: Mud Lark.

This lark was common on the exposed rocky ridges of the Avalon Peninsula. Numerous individuals were seen on the high flat

tundra above Brigus harbor. According to Rooke (1935) it is apparently absent from the open country of the interior.

The single adult male breeding specimen collected on July 6, 1937, is definitely the large, yellow-browed *alpestris*, although noticeably paler above than examples in comparable plumage from Cape Domino, Labrador.

Iridoprocne bicolor (Vieillot). TREE SWALLOW.

Local name: Martin.

Brooks (1936) writes that he saw 7 or 8 over Long Pond and Rooke (1935) saw what he took to be migrating flocks in the Grand Falls region during August, but our party failed to record it in July or September. The "martins" are familiar to the residents of the Brigus region who tell of seeing thousands in August flying over the small ponds.

Perisoreus canadensis sanfordi Oberholser. NEWFOUNDLAND JAY.

Local name: Jay.

This jay is a common, well known resident in eastern Newfoundland. A single specimen was collected by our party at Makinson's Grove, September 1, 1939.

Cyanocitta cristata bromia Oberholser. NORTHERN BLUE JAY.

Rooke (1935) examined a mounted specimen in the possession of J. R. Ewing, taken near St. John's.

Corvus corax principalis Ridgway. NORTHERN RAVEN.

Two ravens were recorded from the interior by Rooke (1935) but there are no records for the Avalon Peninsula.

Corvus brachyrhynchos brachyrhynchos Brehm. Eastern Crow.

Local name: Crow.

Crows are common in the vicinity of Brigus, but like their more southern relatives are very wary.

Penthestes atricapillus bartletti,* subsp. nov. Newfoundland Black-capped Chickadee.

Local name: Pig-a-pee.

Subspecific characters.—Similar to *Penthestes atricapillus atricapillus* but darker and more brownish above, and darker buff on flanks and under tail-coverts. White edgings to wing and tail feathers narrower. Bill larger. In color nearer to *P. a. occidentalis* than to any other known race but much larger.

Measurements.—Adult male (8 specimens in fresh autumn plumage from Newfoundland): wing, 63.5-68 (average 66.12) mm.; tail, 62-63.5 (62.68); total culmen, 10-11 (10.57); tarsus, 16.5-18 (17.25). Adult female (6 specimens in worn breeding plumage from Newfoundland): wing, 61-64 (average 62.33) mm.; tail, 56-60 (58.20); total culmen, 9.5-11 (10.17); tarsus 16-17.5 (16.5).

Type.—Adult male, No. 38031 Cleveland Museum of Natural History; Makinson's Grove, Avalon Peninsula, eastern Newfoundland; September 6, 1938; Raymond Hellmann and David C. Nutt, original number 293.

Geographic distribution.—Newfoundland.

Discussion.—Noble (1919) noted that specimens from western Newfoundland averaged browner, less grayish above and a richer buff on the sides than mainland birds, but considered the difference insufficient to warrant recognition of a distinct subspecies. It is our opinion, however, that a very well marked race is represented in Newfoundland with characters most pronounced in the eastern part of the island and specimens from the western part distinctly

* For Captain Robert A. Bartlett

intermediate with *P. a. atricapillus*. In addition to the 7 specimens in fresh autumn plumage and 4 in worn summer plumage collected by our party on the Avalon Peninsula, there were made available to us by Mr. W. E. Clyde Todd of the Carnegie Museum and Mr. James L. Peters of the Museum of Comparative Zoology, 17 specimens in fresh autumn, worn breeding and immature plumages from western Newfoundland. For comparison with these we had a large series of specimens representing all seasonal plumages of *P. a. atricapillus* from Nova Scotia, New York, Northern Ohio, and Lake Nipissing, Ontario.

For comparison the measurements of the two other sub-species of black-capped chickadee that most closely resemble *P. a. bartletti* are here given.

P. a. atricapillus.—Adult male (6 winter specimens from northwestern New York): wing, 61.5-67 (average 64.5) mm.; tail, 58-65.5 (62); culmen, 8.5-10 (9.1); tarsus, 15-17 (15.9). Adult female (5 winter specimens from northwestern New York): wing, 62-66 (average 63.7) mm.; tail, 59-62.5 (60.7); culmen, 9-9.5 (9.2); tarsus, 15.5-16 (15.6).

P. a. occidentalis.—Adult male (14 autumn and winter specimens from western Oregon and southwestern British Columbia): wing, 59.5-64 (average 62.3) mm.; tail, 55.5-59.5 (56.9); culmen, 9-10 (9.5); tarsus, 14.5-17 (15.5). Adult female (5 autumn and winter specimens from western Oregon and southwestern British Columbia): wing, 58.5-61.5 (average 60.2) mm.; tail, 52.5-57 (54.9); culmen, 9-9.5 (9.2); tarsus, 15.5-17 (16.2).

This species is abundant in all thickets in eastern Newfoundland.

Penthestes hudsonicus littoralis (Bryant). ACADIAN CHICKADEE.

Numerous small flocks of this species were observed at Makinson's Grove where 2 adult males were collected September 6, 1938, and 1 immature male July 5, 1939. It is not as generally common as the black-capped chickadee.

Certhia familiaris (subsp. ?). Brown Creeper.

Rooke (1935) reports seeing 3 brown creepers in the interior and obtaining 1 specimen on Beaver Brook in the Grand Falls region for the first authentic record from Newfoundland. Our party obtained 1 specimen on July 5, 1939, at Makinson's Grove and several others were heard both in July and upon returning in early September. It would seem that the Brown Creeper is not uncommon in the area about Makinson's Grove.

The single specimen obtained is similar to Anticosti Island specimens that are to be described as a new race by F. W. Braund and E. P. McCullagh (manuscript) but is somewhat darker and more rufescent. It is very similar in color to *C. f. zelotes* of the Cascade Mountains of Oregon but smaller, particularly the bill.

With only 1 specimen available for study it would seem best for the present to refer Newfoundland brown creepers to the race soon to be described with type locality Anticosti Island. The only specimen in existence from Newfoundland besides ours is apparently the one taken by Rooke (1935) presumably now in the British Museum.

Nannus troglodytes hiemalis (Vieillot). Eastern Winter Wren.

Brooks (1936) saw 1 at Salmonier and 1 was heard singing at Makinson's Grove, July 5, 1939.

Turdus migratorius nigrideus, subsp. nov. Black-backed Robin.

Local name: Robin Redbreast.

Subspecific characters.—Nearest *Turdus migratorius migratorius*, but darker throughout. Upper parts: gray areas darker, more blackish and black areas more extensive; wings and tail more blackish; back much darker, more blackish mouse gray, in males gray more or less completely obscured by an extension posteriorly of the black of the head. Lower parts: More deeply colored, hazel rather

than cinnamon rufous, with white areas less extensive and black areas more extensive; in male, black streaks of throat tend to coalesce laterally and posteriorly; gray areas of under tail-coverts and under surface of tail darker; black spots on breast of juvenile specimens larger, tending to coalesce anteriorly.

Measurements.—Adult male (5 breeding specimens from Newfoundland): wing, 132-136 (average 134.30) mm.; tail, 102-107 (104.90); exposed culmen, 19-20 (19.60); tarsus, 31.5-36 (34.20). *Adult female* (8 breeding specimens from Newfoundland): wing, 123.5-131.5 (average 126.75) mm.; tail, 91-102 (96.75); exposed culmen, 18.5-20 (19.19); tarsus, 32-35 (33.19).

Type.—Adult male, 38037, Cleveland Museum of Natural History; Hodge Water, Avalon Peninsula, eastern Newfoundland; July 8, 1938; David C. Nutt, original number 159.

Geographic Distribution.—Breeds in Newfoundland. South in winter to eastern Canada and the eastern United States. Specimens have been seen from Nova Scotia, Wolfville, ♂, April 20; New York, Shelter Island, ♂, March 28; Ohio, Geauga County, ♂, March 22, ♀, April 18. The robin is apparently partially a permanent resident in Newfoundland since natives report them to be common about St. John's in the winter months.

Remarks.—This is the most deeply colored of all the American robins and is an exceptionally well marked geographic race. The extremely blackish coloration of the head, neck and anterior back region sets it apart at a glance from all other known forms of *Turdus migratorius*. This melanistic tendency is equally well marked in male, female and juvenile specimens when compared with comparable specimens of the same sex and age from other parts of the species' range. Noble (1919) noted the darker color of Newfoundland robins but did not consider the difference worthy of recognition as a distinct subspecies. The characters of this new race seem to be more intense in eastern Newfoundland than in the western part of the island.

Specimens taken on the Avalon Peninsula include 3 males and 5 females, all taken in July, but additional material from western Newfoundland was kindly lent by Mr. James L. Peters of the Muse-

um of Comparative Zoology: Deer Lake, ♀; Port au Port, ♂, 2 ♀; Nicholsville, ♂. An excellent series of typical *Turdus migratorius migratorius*, including 16 specimens from Northern Ontario and Quebec, was available for comparison through the courtesy of Mr. W. E. Clyde Todd of the Carnegie Museum.

Turdus canadensis Müller (*Systema Naturae* Supplement, 1776, p. 140) was presumably based on breeding robins from the vicinity of Quebec, and that city is hereby fixed as its type locality. Since Quebec robins are like those from the rest of eastern Canada in differing as indicated above from the breeding population of Newfoundland, the name *Turdus canadensis* cannot be applied to birds of the latter region.

This robin is an abundant breeding bird on the Avalon Peninsula but is exceedingly wary as compared with its Ohio relatives. The noisy and precipitous departure of robins while the observer is still as much as 100 yards away is characteristic of birds of that region and elicited the quaint explanation from a resident of Brigus that "the foxes were after them"! This extreme wariness of the robin was also noted by Rooke (1935).

Hylocichla guttata faxoni Bangs and Penard. Eastern Hermit Thrush.

The delightful song of this thrush was often heard issuing from the deepest spruce thickets in the early part of July. None were seen early in September.

Hylocichla ustulata swainsoni (Tschudi). Olive-backed Thrush.

Rooke (1935) saw 1 near Grand Falls on August 21, and was given a specimen from the Avalon Peninsula by J. R. Ewing of St. John's.

Corthylio calendula calendula (Linnaeus). Eastern Ruby-crowned Kinglet.

Local name: Foxy Chub.

This tiny species was common, especially in early September

when many flocks were noted flitting about the thicker spruce growths. A single adult male was collected at Hodge Water, July 7, 1938. Two immature specimens were taken at Makinson's Grove, September 6, 1938, and another September 1, 1939.

Anthus spinoletta rubescens (Tunstall). American Pipit.

Local name: Titlark.

Brooks (1936) records several in the breeding season from the hills overlooking the harbor of St. John's. Our party saw several on July 7, 1939, flitting about the cliffs overlooking Brigus harbor. The pipit would appear to be a common bird on the rocky coast of eastern Newfoundland, but Rooke (1935) found no sign of it in the interior.

Lanius borealis borealis Vieillot. Northern Shrike.

Rooke (1935) reports that a specimen of the northern shrike obtained from Avalon Peninsula was given to him by Mr. J. R. Ewing, a St. John's taxidermist. This is the only record of this species for Newfoundland.

Mniotilta varia (Linnaeus). Black and White Warbler.

According to Rooke (1935) the black and white warbler is common in the interior, but it has yet to be reported from the Avalon Peninsula.

Dendroica aestiva amnicola Batchelder. Newfoundland Yellow Warbler.

Local name: Yellow-hammer.

This is a very common bird in the shrubby areas of the Avalon Peninsula. At Brigus and Hodge Water 5 breeding specimens were collected. Each year upon our return in the first week of September this species, as well as the rest of the warbler population of Avalon Peninsula, seems to have already migrated. On September 10, 1938, while at sea to the south of Newfoundland, a yellow warbler presumably from that island came on board the vessel.

Dendroica coronata coronata (Linnaeus). Myrtle Warbler.

This warbler is uncommon on the Avalon Peninsula, but would seem to be more common in the interior. A single specimen was collected at Makinson's Grove, on July 6, 1939.

Dendroica breviunguis (Spix). Black-poll Warbler.

The black-poll appears to be the most abundant warbler on the Avalon Peninsula although considered rare in the interior of Newfoundland by Rooke (1935). In the low shrubby area at Hodge Water it was seen everywhere, while at Makinson's Grove it preferred the largest, most dense spruce.

On September 1, 1939, a lone female was collected at Makinson's Grove, apparently a straggler, as it is the only warbler recorded by our party during any of the September visits.

In all, 5 specimens were collected. Both male and female breeding specimens average somewhat darker (black streaks more extensive) than comparable specimens from Anticosti Island and Nova Scotia.

Dendroica palmarum hypochrysea Ridgway. Yellow Palm Warbler.

Reported by Rooke (1935) as common and generally distributed in the interior. He also records a specimen from the Avalon Peninsula given him for the British Museum by J. R. Ewing.

Seiurus noveboracensis noveboracensis (Gmelin). Northern Water-thrush.

This species is not common on the Avalon Peninsula. A pair was observed at Makinson's Grove on July 5 and its actions indicated that its nest was close by. Several other individuals were seen. Brooks (1936) states that it was still in song in early August.

The 2 breeding specimens collected are somewhat brighter yellow and more heavily streaked below than a comparable series from Nova Scotia.

Geothlypis trichas brachidactyla (Swainson). NORTHERN YELLOW-THROAT.

Although reported by Rooke (1935) as fairly common in the interior it has not been recorded definitely as yet from the east coast.

Wilsonia pusilla pusilla (Wilson). WILSON WARBLER.

Local name: Yellow-hammer.

This warbler was found to be fairly common in the vicinity of Brigus and at Hodge Water where 3 breeding specimens were collected. It is one of the more common warblers of the Avalon Peninsula.

Setophaga ruticilla ruticilla (Linnaeus). AMERICAN REDSTART.

It is surprising that our party encountered only a few redstarts in view of the fact that Brooks (1936) reports them as almost as common as black-poll warblers. One female appeared to be nesting in Makinson's Grove.

Passer domesticus domesticus (Linnaeus). ENGLISH SPARROW.

This introduced species is common in the streets of Brigus and on the docks at St. John's. Brooks found it common even at some distance from the latter city feeding in open fields with fox sparrows.

Euphagus carolinus (Müller). RUSTY BLACKBIRD.

Local name: Blackbird.

Several small flocks of rusty blackbirds were noted during the course of the field work but its occurrence was decidedly erratic. At Brigus, 2 specimens were taken July 6, 1937, and another was secured at Makinson's Grove, September 6, 1938.

Quiscalus aeneus Ridgway. BRONZED GRACKLE.

Griscom (1926) states that this species has been authentically recorded from near St. John's.

Pinicola enucleator eschatosus Oberholser. Newfoundland Pine Grosbeak.

Although reported as fairly common by Brooks (1936), this species was entirely unrecorded by our party on the Avalon Peninsula. Rooke (1935) collected 1 on August 18 in the Grand Falls region that was in breeding condition.

Acanthis linaria linaria (Linnaeus). Common Redpoll.

Brooks (1936) records the redpoll as very common. This was certainly not the case in the area covered by our expedition, since it went entirely unnoticed. Rooke (1935) saw a flock in the Grand Falls region on August 10 and September 10.

Spinus pinus pinus (Wilson). Northern Pine Siskin.

Brooks (1936) states that he saw many siskins in Bowring Park, St. John's, and according to Noble's (1919) report, it is apparently one of the commonest birds on the west side of Newfoundland. However, this species was not recorded either by Rooke (1935) from the interior or by our party in the Brigus region.

Loxia curvirostra pusilla Gloger. Newfoundland Red Crossbill.

Flocks of red crossbills were a common sight at Makinson's Grove where they were evidently breeding. Some of these birds were to be seen flying recklessly about at almost all times and seeming to pay no attention to our party. An adult female and an immature male specimen were collected at Makinson's Grove, September 6, 1938, and an adult male on July 6, 1939.

Loxia leucoptera leucoptera Gmelin. American White-winged Crossbill.

The white-winged crossbill was likewise common at Makinson's Grove. The single adult male collected on September 6 was in breeding condition, and the plumage was rather worn. This

specimen is of a deeper red and has more blackish flanks and under tail-coverts while an immature specimen taken September 1, 1939, is more blackish than any examples in a large series of male and immature white-winged crossbills from Nova Scotia. In this connection it is significant that Noble (1919) found a tendency toward blackishness in an adult and an immature specimen that he examined from western Newfoundland. It seems very likely that a larger series will show that the Newfoundland white-winged crossbills are a distinct subspecies.

Passerculus sandwichensis labradorius Howe. LABRADOR SAVANNAH SPARROW.

While a very common breeding bird in all open places on the Avalon Peninsula, the Savannah sparrow was especially abundant on the high flats overlooking Brigus harbor. In contrast to this, Rooke (1935) saw only a single individual in the interior of Newfoundland. The 13 specimens taken show that the breeding population of the Avalon Peninsula is perfectly typical of the Labrador race.

Junco hyemalis hyemalis (Linnaeus). SLATE-COLORED JUNCO.

Juncos are recorded by Brooks (1936) as not common on the Avalon Peninsula and our expedition failed to record them at all. However, Rooke (1935) found them more commonly around habitations in the Grand Falls region of the interior.

Zonotrichia albicollis (Gmelin). WHITE-THROATED SPARROW.

White-throats were fairly common at Hodge Water as elsewhere in the forested portion of the island, where their songs were often heard coming from the dense spruce growth. In July 1939, at Makinson's Grove, a continual chorus of their clear ringing notes issued from the woods night and day. Several calls were heard even during a heavy downpour on the morning of July 6, on which day a single female bird was collected. On September 10, 1938, while off the southwestern coast of Newfoundland, a migrating white-throated sparrow came aboard the vessel.

Passerella iliaca iliaca (Merrem). Eastern Fox Sparrow.

Local name: Labrador sparrow.

The fox sparrow is an abundant breeding bird on the Avalon Peninsula. In early July singing males appeared to occupy the tips of practically every prominent spruce, and were in almost continuous song. However, they were very shy and could not be approached closely. Two breeding males and 2 juvenal birds were collected. Judging from Rooke's (1935) experience, fox sparrows are apparently less common in the interior of eastern Newfoundland than near the coast.

Melospiza lincolni lincolni (Audubon). Lincoln Sparrow.

Although recorded by Brooks (1936) as common on the "barrens" of the Avalon Peninsula, and as fairly common by Rooke (1935) in the interior of Newfoundland, the Lincoln sparrow was rare in the region traversed by our expedition.

Melospiza georgiana georgiana (Latham). Eastern Swamp Sparrow.

The Swamp sparrow is by far the most abundant bird observed in the vicinity of Brigus. At the time of the field work there in July, the behavior of these birds indicated nesting activities since, if approached nearer than 50 yards, they ceased singing and continued with high pitched scolding notes from the depths of the underbrush. Their favorite haunts were the wet flats covered by low bog shrubs.

Brooks (1936) also found this species common on the Avalon Peninsula, although strangely enough less common than the Lincoln sparrow. Rooke (1935) found the swamp sparrow localized in one marshy area in the Grand Falls region where it inhabited wetter places than the Lincoln sparrow.

The 5 breeding specimens and 1 autumn plumaged bird collected are apparently intermediate between *georgiana* and *ericrypta*, but somewhat nearer the former race.

BIBLIOGRAPHY OF NEWFOUNDLAND BIRDS

American Ornithologists Union 1931. Check List of North American Birds (fourth edition). Lancaster, Pa., pp. 1-526.

Arnold, E. 1912. A Short Summer Outing in Newfoundland, 1911. Auk, Vol. 29, No. 1, pp. 72-79.

Austin, O. L. Jr. 1932. The Birds of Newfoundland Labrador. Memoirs of the Nuttall Ornithological Club, No. 7, pp. 1-229 Map.

Batchelder, C. F. 1908. The Newfoundland Hairy Woodpecker. Proceedings of the New England Zoological Club, Vol. 4, pp. 37-38.

.....1918. Two Undescribed Newfoundland Birds. Proceedings of the New England Zoological Club, Vol. 6, pp. 81-82.

Bent, A. C. 1912. A New Subspecies of Crossbill from Newfoundland. Smithsonian Institution Miscellaneous Collection, Vol. 60, No. 15, pp. 1-3.

Brewster, W. 1885. The Rock Ptarmigan of Newfoundland. Auk, Vol. 2, No. 2, pp. 193-195.

.....1906. Occurrence of the Lapwing and the Turkey Buzzard in Newfoundland. Auk, Vol. 23, No. 2, p. 221.

Brooks, E. A. 1936. Observation of Some Newfoundland Birds. Auk, Vol. 53, No. 3, pp. 342-345.

Brown, W. J. 1911. Some Newfoundland Bird Notes. Ottawa Naturalist, Vol. 25, pp. 89-94.

.....1912. Additional Notes on the Birds of Newfoundland. Ottawa Naturalist, Vol. 26, pp. 93-98.

.....1912. Unusual Nesting Site of the Pigeon Hawk in Newfoundland. Ottawa Naturalist, Vol. 26, pp. 70-71.

Chapman, F. M. 1932. Handbook of Birds of Eastern North America. D. Appleton and Co., NewYork and London, pp. 1-581.

English, A. 1918. A Gannet Colony. Ottawa Naturalist, Vol. 32, p. 198.

Gilliard, E. T. 1937. The Gannets of Funk Island. Auk, Vol. 54, No. 3, pp. 379-381.

Griscom, L. 1926. Notes on the Summer Birds of the West Coast of Newfoundland. Ibis, twelfth series, Vol. 2, No. 4, pp. 656-684.

Gross, A. O. 1937. Birds of the Bowdoin-MacMillan Arctic Expedition, 1934. Auk, Vol. 54, No. 1, pp. 12-42. pl. 2-5.

Howe, R. H. Jr. 1900. A New Subspecies of the Genus *Hylocichla*. Auk, Vol. 17, No. 3, pp. 270-271.

.....1913. A few Notes on Newfoundland Birds. Auk, Vol. 30, No. 1, pp. 114-115.

Ingersoll, E. 1928. Lapwings Invade Newfoundland and Canada. Auk, Vol. 45, No. 2, pp. 208-210.

Lewis, H. F. 1922. The Mourning Dove in Newfoundland. Auk, Vol. 39, No. 1, pp. 106-107.

Lloyd, Hoyes 1939. Banded Kittiwake from Russia recovered in Newfoundland. Canadian Field Naturalist, Vol. 53, No. 2, pp. 29-30.

Lucas, F. A. 1890. The Expedition to Funk Island with Observations upon the History and Anatomy of the Great Auk. Annual Report of the Smithsonian Institution, U. S. National Museum, 1887-1888, pp. 493-529.

Noble, G. K. 1919. Notes on the Avifauna of Newfoundland. Bulletin of the Museum of Comparative Zoology, Vol. 62, No. 14, pp. 543-568.

Oberholser, H. C. 1914. Four New Birds from Newfoundland. Proceedings of the Biological Society of Washington, Vol. 28, pp. 43-45.

Porter, L. H. 1900. Newfoundland Notes. Auk, Vol. 17, No. 1, pp. 71-73.

Reeks, H. 1869. Notes on the Zoology of Newfoundland. Zoologist, 2nd series, Vol. 4, pp. 1609-1614; 1689-1695; 1741-1759; 1849-1858.

Rooke, K. B. 1935. Observation on the Birds of Newfoundland during the 1934 Expedition of the Public Schools Exploring Society. Ibis, thirteenth series, Vol. 5, No. 4, pp. 856-879.

Stejneger, L. 1884. A New Subspecies of Willow Grouse from Newfoundland. Auk, Vol. 1, No. 4, p. 369.

Stuart, G. H., 3rd. 1920. Nesting of the Greater Yellow-legs in Newfoundland. Auk, Vol. 37, No. 2, p. 292.

Wynne-Edwards, V.C. 1935. The Newfoundland Gannet Colony; with Recent Information on the other North American Gannetries. Ibis, thirteenth series, Vol. 5, No. 3, pp. 584-594.

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BIRDS OF THE WHITE-FULLER EXPEDITION TO KENYA, EAST AFRICA

By
HARRY C. OBERHOLSER

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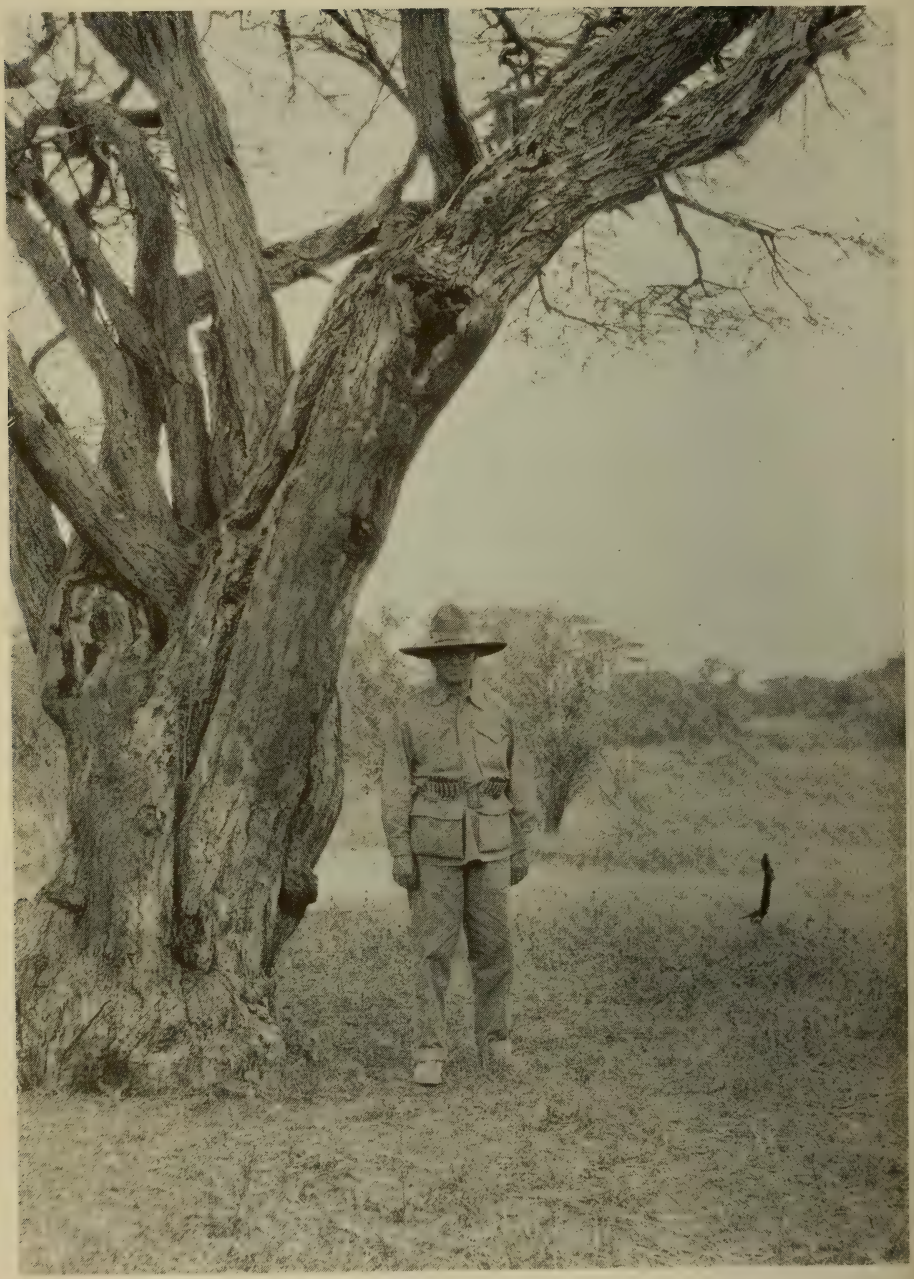

MR. WINDSOR T. WHITE UNDER AN ACACIA USED AS A 'RUBBING-TREE' BY ELEPHANTS, NEAR GARBA TULA. March 2, 1930.

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INTRODUCTION

The present report details the ornithological results of an expedition to Kenya Colony, East Africa, led by Mr. Windsor T. White of Cleveland, Ohio, a trustee of the Cleveland Museum of Natural History. Accompanying Mr. White was Mr. Arthur B. Fuller, the Curator of the Department of Exhibits in this Museum.

The purpose of this expedition was to obtain mammals and birds for the collection of the Cleveland Museum of Natural History. Although particular emphasis was laid on the larger mammals, such as antelopes, there were brought back some 610 large and small birds, representing 197 species and subspecies. A few of these have hitherto not been recorded from the colony of Kenya. A number of changes in nomenclature will be found under the appropriate headings in the list of species, including the creation of 2 new genera for species that seem out of place in the groups to which they have heretofore been referred.

The colony of Kenya is, perhaps, so far as its birds are concerned, the most explored and best-known part of Africa. Notwithstanding this, the present collection, although it contains no new species or subspecies, does add something to the knowledge of the geographical distribution of birds within the area.

Some of the rare or otherwise interesting birds included in this collection are:

Oxyura maccoa
Nyroca erythrophthalma
Pternistis leucoscepus keniensis
Rhynchodon peregrinus perconfusus
Polihiërax semitorquatus castanonotus

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Polemaëtus bellicosus
Cursorius cursor meruensis
Caprimulgus fossei apatelius
Heterotrogon vittatus keniensis
Buccanodon leucotis kenyae
Tmetothylacus tenellus
Pycnonotus dodsoni peasei
Stelgidillas gracilirostris percivali
Phyllastrephus finschi placidus
Turdus olivaceus elgonensis
Campephaga quiscalina münzneri
Alseonax gambagae somaliensis
Apalis melanocephala nigrodorsalis
Cisticola cinereola schillingsi
Oriolus monacha percivali
Pomatorhynchus australis littoralis
Stilbopsar kenricki
Crithagra burtoni albifrons
Fullerellus donaldsoni

By reason of these and other considerations it seems worth while to publish a list of the specimens obtained, together with the data pertaining to them. Mr. Fuller procured most of these birds, and unless someone else is mentioned it is to be understood that he is the collector. Additional species of which no specimens were obtained are marked with an asterisk.

The colors of the unfeathered parts given for many of the birds were by Mr. Fuller in the field matched with the plates of Ridgway's 'Color Standards and Color Nomenclature,' thus ensuring an accuracy that for African birds, so far as the writer is aware, has not before been attained. These color notes are in quotation marks in the specimen lists.

The total length of specimens given under each was measured in the flesh by the collector. All measurements are in millimeters.

The circumstances under which this expedition traveled allowed little time or opportunity for making field notes on the habits of the birds observed; but such notes as were brought back by either Mr. White or Mr. Fuller are added in brackets over their initials to the accounts of the species to which they pertain.

The full-page halftone plates are all from photographs taken by Mr. White or Mr. Fuller. The map was drawn by Lynn C. Jackett. The course of the expedition is detailed in the following account furnished by Mr. Fuller.

ITINERARY

"The expedition, under the leadership of Mr. Windsor T. White, sailed from New York on January 17, 1930, on the steamer

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Ile de France, and reached Nairobi in Kenya Colony, East Africa, at about noon on February 18.

"Our motorized safari began at 11:00 A.M. on February 22, when our 5 trucks rolled out of Nairobi and headed north, stopping for the night at Nyeri.

"On the following morning we proceeded through Nanyuki and Isiolo to Archer's Post, where our base camp was located and where supplies for the expedition had already been stored. Our tents we pitched about a half mile south of the Northern Uaso Nyiro, on some high ground and in the shade of some large flat-topped acacias. From the front of our tents, which faced the river, one could easily mark the river's course by the fringe of dom palms along its banks. Across the river to the north one could see some rather rocky hills covered with sparse brush, probably the southernmost foothills of the Mathews Range. While the tents were being pitched I noticed that the temperature in the shade registered 86° Fahrenheit.

"We collected in the vicinity of this camp until March 2, when we started eastward for the Tana River where Mr. White expected to hunt elephants. We traveled by way of Garba Tula and Maddo Gashi. On March 3 we left King's Camp 12 miles east of Garba Tula in the early morning during a light rain. Turning southeastward at Maddo Gashi we ran into gumbo 24 miles out, having driven largely in first or second gear for about 30 miles. Here, 147 miles by car from Archer's Post, we were forced to turn back and abandon the trip to the Tana River, since it seemed useless in view of such difficult going and the fact that the rains would scatter the elephants, which would not now have to go to the river for water. Besides, if the rains continued our whole expedition might have been jeopardized. We spent the night at Maddo Gashi, which consisted of 4 store huts and a handful of Somali traders who get hides from the natives.

"The next day, March 4, we retraced our tracks 102 miles, and made camp on the south bank of the Northern Uaso Nyiro, 21 miles east of Archer's Post. Our tents were pitched facing the river on a grassy knoll with a large marsh between camp and the highway. Here we collected specimens until March 8, when we broke camp and returned to Archer's Post, where we made ready for our trip to the north.

"On the morning of March 11, at about 7 o'clock, Mr. Weir of the Public Works Department came with 60 of his boys, making altogether 100 including our own, who by hitching 200 feet of rope to one of our cars dragged it across the river. After drying off the car somewhat so that the motor would start, the 4 other cars were soon pulled across the river and we were on our way. The road twisted and turned through the thorn scrub which became more scattering as we progressed northward, and both grass and game became scarce.

"On the same day we arrived at Kinya, about 39 miles north of Archer's Post, where we made camp for the night, moving on March 12 to Lasamis which lies about 68 miles north by east of Archer's Post. Camp here was at an altitude of 2100 feet on a sand lugger (dry stream bed) in fine open country.

"Collecting was carried on here until the morning of March 16, when we broke camp at 6:30 A.M. and crossed the Kasut Plain, at an altitude of about 1800 feet, 25 miles from Lasamis. The ride across the plain was delightful, as everything was green from recent rains and in many places the ground was carpeted with flowers. On one stretch of several miles these formed an almost solid mass of yellow, at a distance somewhat resembling wild mustard in bloom in a grain field at home in Ohio. In the middle of this area there was a big flock of Marabous and White Storks mixed together, and one of the latter was collected as a specimen.

"To our Crater Lake camp site the speedometer showed the distance to be 53 miles from Lasamis. The last 3 miles were up the side of the mountain on an old cattle trail badly washed by recent rains. Camp was pitched in an opening about as low as the edge of the crater at 4550 feet altitude, and a short distance below the dilapidated huts previously used by Martin and Osa Johnson. Across the lake are heavy woods which extend all around the lake with the exception of the break where on the western side our camp was situated. These woods extend down the side of the mountain for about 3 miles, where one leaves the forest and enters the low foothills covered with lava boulders, grass, and some scattering thorn scrub. Marsabit is east of the lake and 7 miles away.

"Crater Lake is about a quarter of a mile in diameter and almost circular. A grassy slope extends about a hundred yards or more from the tall rushes and cattails at the water's edge to the dense forest which rises rather steep and rocky a hundred feet to the brim of the crater. This forest reaches several miles to the northeast but stops abruptly on the southwestern side about 3 miles below the lake, whence open hills, rocky and grassy, take its place down to the desert. The fringe of rushes and reeds forms a dense mass about 6 feet high above the soft mud around the shore, and there the croaking notes of frogs and coots could be heard continually.

"At the time of our stay there were 100 or more ducks on the lake and a lot of European Coots, also a few small grebes, an occasional Hammerhead Stork, and a large heron (*Ardea cinerea*), similar to the North American Great Blue Heron. There was a kind of shrike which used to sit on an occasional dry bush near the rushes, and I collected 2 specimens. Doves came down to drink; and swallows were very abundant. A few kites sailed around overhead. Common here was the African stiff-tailed Maccoa Duck, very much resembling the American Ruddy Duck. Another, the African Pochard, which appears much like our Scaup Duck, but without so much white, was the most numerous of all.

"As the rushes were about 25 to 50 yards across, and the mud soft and oozy, we had great difficulty in recovering our specimens after they were shot. The black boys are much afraid of snakes and marshes, and most of them swim but little if at all, so we had to shoot only in chosen places. I tried swimming after one duck, but about 20 yards off the rushes I encountered soft oozy muck which hindered my movements and made my return to shore very difficult

and rather terrifying. It was a great relief to reach the shore with my well-earned prize, and I did not make another such attempt.

"Every morning we were in a dense cloud mist which forms between 4 and 6 o'clock and lasts from 3 to 6 hours, clearing up usually about 10 or 11 o'clock. The natives claim that this occurs during every month in the year, except one. The temperature in the morning and evening was around 65°, and in the afternoon it was usually between 80° and 85°. Mosquitoes were nearly absent. but ticks numerous and chiggers common. We stayed at Crater Lake from March 16 to March 20, and left for Lasamis at 7:30 A.M. on the latter date, arriving at our former Lasamis camp site at 12:45 P.M.

"On March 21 and 22 my guide and I returned to Archer's Post and packed up all our specimens to insure their being in good condition on our return from our proposed trip to Mount Kulal and Lake Rudolf. We lined our boxes with brown paper, fastened in with flour paste, and sealed them tight after putting in liberal allowances of naphthalene and paradichlorobenzine.

"On our way back to Lasamis we discovered that there had been a heavy shower a few miles north of us, and we became somewhat concerned about being able to return, but we found that the sand luggers (dry creeks) filled with sand were even easier to cross than when dry, as the moisture kept the sand from being loose. Then, too, the country was mostly hilly and rocky, with little or no gumbo or cotton-soil which gets sticky or slimy.

"On the morning of March 23 we were off to an early start toward Mount Kulal, breaking camp at 6:06 o'clock and found that the recent showers had made the road slippery and wet, but we covered the first 40 miles in about 3 hours. In places the boys would all push to get us out, and even so we sometimes had to use one car to pull the others through. We crossed the Kasut Plain, and thence wended our way over lava-strewn areas and stretches of grassy, bushy, and sandy land. As we progressed farther north the brush became smaller and scarcer, and sand or lava became more and more evident in the landscape, until sometimes we traveled as far as 5 miles without encountering vegetation. On level stretches we could move as fast as 35 miles per hour. Some of these flat pans must be quite impassable in wet weather.

"On the same day we arrived at Koroli, which consists of a well, dug by the government for the use of natives and their herds, and pitched our camp about a mile from the well on a higher grassy and sandy plain, 80 miles from Lasamis. It was hot and sultry, the temperature 95°F. We could plainly see Mount Marsabit to the southeast, and Mount Kulal to a little north of west. This locality is covered with lava rock except in certain places along the edge of the escarpment, and in these low spots and stretches lies the game country.

"We collected around Koroli until the morning of March 28, when we headed for Balessa, a camel camp about 50 miles toward

Mount Kulal. The trail turns and twists through scattered thorn scrub about the height of one's head, this mingled with short grass and occasional small plants and shrubs.

"Every day after leaving Kinya we saw (except at Marsabit) thousands to millions of locusts, and on the road toward Balessa these became even more numerous. It seems that they breed there and then fly south into cultivated areas like Meru, Nanyuki, and Nyeri, where they devastate the crops.

"Camp at Balessa was pitched on a knoll about a hundred yards from a sand lugger with the usual fringe of large thorn trees, but almost no water. The tents faced northwest and directly toward Mount Kulal, which practically fills the horizon. The crest of the mountain was then hidden by clouds; its slopes are cut by ravines, steep-sided and dark with shadows. The slopes are covered with grass, scattered thorn scrub up to 5 or 6 feet in height, and with lava boulders. The altitude at camp was about 850 feet higher than Koroli, and approximately 2700 or 2800 feet. The temperature at 2:00 P.M. was 98°F.

"On the morning of April 1 we, with 17 camels and 4 horses, started up the slopes of Mount Kulal. Many times we had to lead our horses over the piles of loose rocks. At mid-day we made camp about half way up the gradual slope toward the place where we expected to have our hunting camp. The altitude of this stopping point is 3500 feet. On April 2 we proceeded up the slope of Mount Kulal, and soon we began to meet with scattered tall acacias, which became fairly plentiful at an altitude of 4000 to 4500 feet.

"We decided to camp in a pass of glade-like character at the foot of a cliff, between two peaks, at an altitude of about 5000 feet. This is a beautiful open country, very hilly, with deep, steep-sided ravines, grassy slopes with scattered small trees, with lava scoria almost everywhere we walked. The view from our tents stretched out to the south with the southern end of Lake Rudolf visible in the distance, backed by hills and mountains on its western and southern sides. On this western side Mount Kulal slopes at about 30° down to an open plain which fringes the lake. The summit of the hill above this camp is about 6500 feet in altitude, rather flat-topped, covered with green grass about knee deep, and dotted with tall cedars which in places become rather thick groves. Broken lava boulders and loose scoria thickly strewn and hidden by the grass make walking very difficult. The view northeastward from this hill is really grand. Just in front and about a thousand feet or more below is a deep, steep-sided canyon, and across it the mountain rises from the sheer canyon walls to grassy plateaus and slopes, and beyond to the rain forest which covers the top of this 7738-foot mountain. The southern end of Lake Rudolf presents an interesting view from the site of our camp, being plainly visible, nestled in among the barren ranges of low hills and mountains. The mornings here were usually cloudy or misty and we had several rains during our 4 days and 5 nights at this camp. The ordinary morning temperature was

around 65°, and once it was down to 63°. On April 7 we moved back down to our Balessa camp 15 miles by trail southeast of the Mount Kulal camp.

"On the morning of April 9 we started from Balessa for Lake Rudolf, going about 14.5 miles west and southwest to the turn of the trail, and thence north on harder ground to Sirima, about 25 miles from Balessa, and the end of the trail, the nearest point to Lake Rudolf to which any motor car had been to that day. However, we continued, though we had to work our way across a lava plain for about 3 miles, where all the boys except the drivers had to go ahead and remove rocks so the trucks could get through. We finally, because boulders were so numerous that we could go no farther, made temporary camp 34 miles from Balessa, and about 700 feet above the lake on the edge of the escarpment.

"On the next day (April 10) we went down to the lake, a distance of about a mile and a half, to explore for a camp site. We found an old camel trail and made the distance in about an hour, practically all the way over lava slag and boulders, which also extend out into the lake. At this point we finally set up our camp at an altitude of about 1340 feet above sea level.

"Vegetation is very sparse here, the region uninviting and inhospitable. Intense heat and high winds continued during all the time that we spent here; and, with the exception of good fishing, also bird life and crocodiles along the shore, there was little of interest in either animal or plant life. The landscape is just rock, rock, rock, everywhere, from the shore to the horizon; and this end of the lake is surrounded by mountains which are largely cinder cones, some of them smooth and red, thus appearing to be of very recent origin. The chief vegetation along the shore was a short, stiff, sharply pointed grass, painful for either walking or sitting. Most of my collecting here was done from a stone blind on a point not far from camp, and during some sorties along the shore.

"On April 14 we removed again to Koroli to do some collecting in that vicinity. On the morning of April 15 we drove out northeast of camp toward Lake Koroli, which is alkaline and practically evaporates during the dry season. The country here opens out into a rolling grassy plain of sandy soil, and our further progress was finally stopped by a soft sand lugger. Amongst the sandhills above the lugger we found numerous small ponds or lakes which had sprung into existence during the recent rains.

"We continued operations at the Koroli camp until the morning of April 19, when we returned to our old camp at Lasamis after a drive of 80 miles through the thorn bush country. We spent the next day (April 20) reorganizing our equipment.

"On April 21 my guide and I drove down to Archer's Post, and until we returned to Lasamis on the evening of April 25 we spent the time labelling, cataloguing, and packing specimens for shipment.

"April 26 was another day of moving, and this time we went back to a point just south of the Merile lugger into a country more

rolling and hilly than that about Lasamis; but the ground was covered with lava scoria hidden in the grass and weeds, by reason of which walking was very disagreeable.

"On April 29 we removed camp to a point some 16.5 miles from Merile, also about 5 to 7 miles north of our first camp at Kinya, and on high ground just north of the place where the road crosses the Kinya lugger. Pests were not abundant here, mosquitoes being scarce, and only an occasional sand fly or tsetse fly, with a few horse flies present to bother one. The guides say that the height of the rainy season comes between April 20 and May 20.

"The next camp was made on May 5 about 8 miles north of the Northern Uaso Nyiro at a place called Kisima Kufuta, or The Well. On the small plain not far from this camp the plants and grass are about knee deep, lush, and green. A white feathery flower is abundant and the thorny bushes that are scattered over the plain are about 20 to 30 feet in height. Here and there the green is broken by brown rocks and red termite hills, which look almost like piles of bricks about 6 or 8 feet high. Collecting was carried on around Kisima Kufuta from May 5 until May 15, when we removed camp to the high flat hill on the northern shore of the Uaso Nyiro at Archer's Post.

"This wonderful scenic location overlooks a wide expanse of country. Mount Kenya looms up a little to the east of south, and northward tapers down to meet the Jombeni Range, which lies a little west of south; and stretching away to these as far as the eye can see there extends a flat open country with plains, and with trees which appear to be more numerous in the distance. The weather was fine and clear, and the large amount of snow visible on Mount Kenya was said to be a sure sign that the rains were over.

"On May 17 we moved south across the Northern Uaso Nyiro. The river was in flood, so the automobiles and our luggage had to be taken across on a cable, which was a difficult task requiring a lot of hard work and engineering skill. We stopped at Creek Camp 10 miles south of Archer's Post and toward Isiolo, pitching our tents in an open park of big acacias just south of Isiolo Creek.

"On the next day we divided our party, Mr. White and most of the outfit going on to Nairobi, while my guide and I left for the slopes of Mount Kenya for a side trip on which we took only 2 of the cars and a few boys. This trip took us to Isiolo where the District Commissioners' office was situated, and we realized that after nearly 3 months we were again in touch with civilization.

"Thence our journey was over grassy, rolling plains with a scattering of thorn scrub; and finally after entering the cedar and olive tree zone we came to the little crater lake called Gunga Lake, named for the myriads of frogs, which sounded like our Ohio spring peepers. As night came on their chorus would start. This lake is only a short distance from the road, and we made camp on high ground above the lake. Our evening meal was enjoyed under the olive trees with a cheerful fire of cedar logs, which was welcome as

the air at this altitude is chilly at night. It rained during the night and when we went forth to hunt bushbuck on May 19 we found the vegetation drenching wet. Our course took us around the eastern end of the lake where we could look out over an expanse of rough ground covered with tall grass and other vegetation often higher than one's head, and here and there patches of forest, some only a few yards in extent, others covering several hundred yards, a favorite haunt of the bushbuck. After breakfast we drove to Meru through some heavy forest with a tangle of underbrush and vines. In some places stinging nettles even higher than one's head would cover a considerable area. We went to the sawmill where W. W. Bowen had stayed for a month only the previous year, and where he had collected about 300 birds. We had delightful weather during our stay at this Gunga Lake camp, with temperatures about as follows: 6:00 A.M., 52°; Noon, 70°; 8:00 P.M., 62°. On May 25 we attempted to collect some ducks on the lake, but without success. I worked around the crater walls for some distance but found the going extremely difficult, with the ground steep and soft, and with interference from a tangle of vines, creepers, shrubs, and trees. On May 26 by following the logging roads and elephant trails, we collected in the dense forest at Meru above the sawmill, and obtained 18 birds. It was delightful in this forest, cool, but with spots of sunlight filtering through. There was added attraction from the various strange and musical notes of the birds, and here and there a butterfly of gorgeous color flitting about. However, there were innumerable ants, and abundant stinging nettles in the openings between the trees, which were not so pleasant.

"On May 31 we broke camp and drove as far as Nanyuki, spending the night there on Captain A. F. Ayre's 10,000-acre cattle ranch. This area is mostly grassland and cedars, the altitude about 6500 feet, and commands an excellent view of Mount Kenya whose snow-capped, jagged peaks occasionally came into view when the clouds lifted. At daybreak the temperature registered 46° Fahrenheit.

"On June 1 we drove to Nyeri; and on June 2 we arrived back again at Nairobi."

COLLECTING AND OBSERVING STATIONS

Archer's Post.—About 145 miles[1] north northeast of Nairobi. Altitude, about 1800 feet.

Balessa.—About 50 miles west of Koroli. Altitude about 2750 feet. This station is about 8 miles southeast of the summit of Mount Kulal. It is not the Balessa of most maps, which lies about 60 miles north northeast of Mount Kulal.

Cole's Plains.—A short distance south of Isiolo.

Crater Lake.—About 7 miles west of Marsabit. Altitude 4500 feet. This lake was called Lake Paradise by Martin Johnson, but it

[1]All distances here given have been measured in a straight line on the map.

is known locally as Crater Lake. It is about a quarter of a mile in diameter and nearly circular. About 100 yards or more of grassy slope extends outward from the tall rushes of the lake's margin to the dense forest that rises about 100 feet to the brim of the crater.

Gunga Lake.—About 10 miles northwest of Meru. Altitude, 5834 feet.

Isiolo (Iscolo).—About 25 miles a little west of south of Archer's Post on the road to Nairobi. Altitude, about 3300 feet.

Kasut Plain.—About 25 miles north of Lasamis. Altitude, about 1700 feet.

Kinya.—About 39 miles east of north of Archer's Post. Altitude, about 3100 feet.

Kisima Kufuta.—About 8 miles north of Archer's Post. Altitude, about 1800 feet.

Koroli.—About 30 miles northwest of Marsabit. Altitude, 1900 feet.

Lake Rudolf, southeastern shore, about 2 miles north of the southern end of South Island.—Altitude, 1335 feet.

Lasamis.—About 68 miles north by east of Archer's Post. Altitude, 2090 feet.

Maddo Gashi.—About 115 miles east of Archer's Post. Altitude, about 975 feet.

Marsabit.—About 120 miles a little east of north of Archer's Post. Altitude, about 4500 feet.

Merile.—About 10 miles south of Lasamis. Altitude, about 1900 feet.

Meru.—About 10 miles northeast of Mount Kenya. Altitude, about 5200 feet.

Mount Kenya.—About 85 miles north northeast of Nairobi. Altitude, 17036 feet.

Mount Kulal.—Its highest point is about 18 miles east of the southern end of Lake Rudolf and about 23 miles north of the same point. Altitude, 7738 feet. The collecting station of this expedition was about 3 miles south of the highest peak, and at an altitude of about 5000 feet.

Nanyuki.—About 60 miles southwest of Archer's Post, and about 100 miles east of north of Nairobi, on the road from Nairobi to Archer's Post. Altitude, about 6500 feet.

Northern Uaso Nyiro (Northern Guaso Nyiro).—Camp about 21 miles east of Archer's Post. Altitude, about 2600 feet.

Nyeri.—About 30 miles southwest of Mount Kenya. Altitude, 5943 feet.

LITERATURE

Much has been written regarding the birds of Kenya, but the few publications most important for their study seem to be as follows:

Friedmann, Herbert. Birds Collected by the Childs Frick Expedition to Ethiopia and Kenya Colony. Bulletin of the United States National Museum, No. 153; Part 1, Non-Passeres, 1930; Part 2, Passeres, 1937.

Jackson, Frederick John; and Sclater, William Lutley. The Birds of Kenya Colony and the Uganda Protectorate, Vols. I-III, 1938.

Reichenow, Anton. Die Vögel Afrikas, Vols. I-III, 1900-1905.

Sclater, William Lutley. Systema Avium Ethiopicarum; Part 1, 1924; Part 2, 1930.

ACKNOWLEDGMENTS

For courtesies in connection with the preparation of this report the author wishes to thank Doctor Herbert Friedmann, Curator of Birds at the United States National Museum, Washington, D. C. His bulletin on the birds of Ethiopia (Abyssinia) and Kenya is the most useful piece of literature on the birds of eastern Africa.

It is obvious that the present writer is deeply indebted to Mr. Arthur B. Fuller for information regarding the country, its topography, and facts regarding the expedition; as well as for much other assistance.

This report now appears in print by reason of the generous interest of Mr. Windsor T. White, who provided funds for its publication.

LIST OF BIRDS COLLECTED OR OBSERVED

Family STRUTHIONIDAE

***Struthio camelus molybdophanes** Reichenow

Struthio molybdophanes REICHENOW, Mitt. Ornith. Ver. Wien, 1883, p. 202, pl. S (Somaliland).

[Two young Somali ostriches were on March 30 brought by natives into our camp at Balessa. After being examined and photographed they were released.

Ostriches, though occasionally seen along our route, were not numerous. A. B. F.]

Family COLYMBIDAE

Tachybaptus ruficollis capensis (Salvadori)

Podiceps capensis SALVADORI, Ann. Mus. Civ. Stor. Nat. Genova, Ser. 2, Vol. 1, September, 1884, p. 252 ("Rugghiè, Scioa").

Two specimens:

Adult male, Crater Lake (Lake Paradise), March 17, 1930. Length, 262 mm.

Adult female, Koroli, April 15, 1930. Length, 254 mm. "Iris brown."

[At Crater Lake a few individuals were seen on March 18; at Koroli 1 was collected from a pond in the sandhills on April 15; and on March 21 at Archer's Post 1 was observed in a pool of water left by recent showers.—A. B. F.]

The group of grebes closely related to the present species and currently treated as a part or a subgenus of the genus *Poliocephalus* Selby, seems sufficiently well and trenchantly defined to be recognized as a separate genus. For this the name *Tachybaptus* Reichenbach[1] is available.

[1]Avium Syst. Nat., 1852 [1853], p. iii (type by original designation *Colymbus minor* Gmelin = *Colymbus ruficollis* Pallas).

Family PHALACROCORACIDAE

Phalacrocorax carbo lugubris Rüppell

Phalacrocorax lugubris RÜPPELL, Syst. Uebers. Vog. Nord-Ost-Afr., 1845, p. 134, pl. L. ("abyssinischen Flüsse und Seen" [=Ethiopia]).

Two specimens, from Lake Rudolf:

Adult female, April 11, 1930. Length 749 mm. "Iris green; pouch yellow ocher."

Female in first winter plumage, April 11, 1930. Length, 800 mm.

[Several large cormorants were noted on April 10 along the shore of Lake Rudolf near our camp.—A.B.F.]

Although certain individuals of this race are proportionately large as compared with *Phalacrocorax carbo lucidus* of South Africa, the average size of the latter is greater and indicates that it is a different race.

Haliëtor africanus africanus (Gmelin)

[*Pelecanus*] *africanus* GMELIN, Syst. Nat., Vol. 1, Part ii, April, 1789, p. 577 (Africa [restricted type locality, White Nile District[1]]).

Three specimens, from Lake Rudolf:

Adult female, April 12, 1930. Length, 546 mm. "Iris nopal red; eyelids pallid violet blue; bare skin around eyes pale yellowish glaucous washed with pale flesh color; bill clove brown above, raw sienna below, naples yellow at base."

Immature male, April 12, 1930. Length, 572 mm. "Iris nopal red; legs and feet, black."

Immature, unsexed, April 12, 1930. Length, 521 mm. "Iris spectrum red; bare skin around eyes honey yellow, touched with olive ocher; bill clove brown above, antimony yellow below."

The second individual listed above is in full molt of body plumage and has already acquired a considerable number of the black feathers. The third bird is in the brown plumage from which it has just begun to molt, as evidenced by a few black feathers appearing in the brown and the white areas.

[Several of these small cormorants were observed on April 10 on the shore of Lake Rudolf near our camp. The same species was fairly common on April 11 along the shore of the lake.—A.B.F.]

Family PELECANIDAE

*Pelecanus roseus Gmelin

[*Pelecanus*] *roseus* GMELIN, Syst. Nat., Vol. I, Part ii, April, 1789, p. 570 ("insula Manila" [Philippine Islands]).

[One white pelican was seen on April 10 sitting on a rock along the shore of Lake Rudolf not far from our camp. Another, or the same individual, was noted on the shore of the same lake on the following day.—A.B.F.]

[1]C.H.B.Grant, The Ibis, Ser. 10, Vol. III, No. 1, January 8, 1915, p. 75.

Family ARDEIDAE

*Ardea cinerea cinerea Linnaeus

[*Ardea*] *cinerea* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 143 ("Europa" [restricted type locality, Sweden]).

[An occasional individual of this species was observed near Crater Lake on March 18. Two were seen on February 24 in a marsh of cattails and rushes near camp at Archer's Post.—A.B.F.]

Ardea melanocephala Vigors and Children

Ardea melanocephala VIGORS and CHILDREN, in Denham and Clapperton, Narrative Travels and Discoveries North. and Cent. Afr., Vol. II, 1826, Appendix XXI, p. 56 (no locality; probably near Lake Chad).

Two specimens:

Adult female, Archer's Post, Northern Uaso Nyiro[1], March 6, 1930. "Iris olive; lores light grape green; upper mandible black; lower mandible fleshy white tipped with green; legs and feet, black."

Female in first winter plumage, Crater Lake, March 18, 1930. Length, 914 mm. "Iris amber yellow; bare skin around and in front of eyes, light dull green yellow; upper mandible black; lower mandible pallid purplish gray; legs and feet, sooty black."

*Pyrrherodia purpurea purpurea (Linnaeus)

[*Ardea*] *purpurea* LINNAEUS, Syst. Nat., Ed. 12, Vol. I, 1766, after May 24, p. 236 (" in Oriente").

[One was met with on April 10 along the shore of Lake Rudolf.—A.B.F.]

*Egretta garzetta garzetta (Linnaeus)

[*Ardea*] *Garzetta* LINNAEUS, Syst. Nat., Ed. 12, Vol. I, 1766, after May 24, p. 237 ("in Oriente").

[Two egrets of this species were seen on February 24 in a marsh near camp at Archer's Post.—A.B.F.]

Bubulcus ibis ibis (Linnaeus)

[*Ardea*] *Ibis* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 144 ('in Ægypto").

Two adult females, from Koroli, collected on March 25, 1930. Length of each, 508 mm. "Legs deep brownish vinaceous, their joints deep colonial buff; feet chamois."

[A few of these egrets were noticed on April 10 and 11 on the shore of Lake Rudolf.—A.B.F.]

Family SCOPIDAE

Scopus umbretta bannermani C.H.B.Grant

Scopus umbretta bannermani C.H.B.GRANT, Bull. Brit. Ornith. Club, Vol. XXXV, No. CCI, November 24, 1914, p. 27 ("Mt. Leganisho, 6600 feet, British East Africa").

[1]Sometimes spelled Guaso Nyiro.

A single specimen, an adult female, taken at Kinya, March 11, 1930. Length, 533 mm.

[An occasional Hammerhead Stork was noted near Crater Lake on March 18.—A.B.F.]

Family CICONIIDAE

Ciconia ciconia ciconia (Linnaeus)

[*Ardea*] *Ciconia* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 142 ("Europa, Asia, Africa" [type locality restricted to Sweden]).

Two specimens, from the Kasut Plain:

Adult female, March 23, 1930, Windsor T. White. Length, 991 mm.

Adult female, March 16, 1930. Length, 1067 mm. "Iris dark brown; eyelids black; bill and feet, brazil red."

[Thousands of white storks, along with ibises, geese, and ducks were met with on March 23 at Koroli.—W.T.W.]

[This stork was first seen on February 23 over the northwestern side of Mount Kenya not far from Nanyuki. There several hundred individuals were milling about at such a great height that they were barely visible, in what was apparently a migratory movement. On the Kasut Plain on March 16 there was a large flock feeding on locusts.—A.B.F.]

Leptoptilos crumeniferus (Lesson)

Ciconia crumenifera LESSON, Traité d'Ornith., Livr. 8, June 11, 1831, p. 585 ("Sénégal").

One unsexed adult is from Archer's Post and was collected on March 7, 1930. Length, 1159 mm. "Iris brown, head black, becoming brownish vinaceous posteriorly; neck pale vinaceous fawn; legs and feet, fuscous black."

[In one place on the Kasut Plain where the wild flowers were all yellow reminding one of wild mustard, on March 16, a big flock of Marabou Storks mixed with European White Storks was feeding on locusts.—W.T.W. and A.B.F.]

Family THRESKIORNITHIDAE

Threskiornis aethiopicus aethiopicus (Latham)

[*Tantalus*] *æthiopicus* LATHAM, Index Ornith., Vol. II, 1790, p. 706 ("Æthiopia").

One adult female, from Koroli, taken, March 24, 1930. Length, 686 mm. "Iris dark brown; bill, with bare skin of head and neck, black; skin on sides of breast nopal red; legs and feet, taupe brown."

This specimen, which is in breeding condition, has the tips of the greater wing coverts, the outer edges of the primary coverts, the terminal portion of the axillars, and the long feathers of the sides of the body in color from ochraceous buff to ochraceous tawny.

Family ANATIDAE

Oxyura maccoa (Eyton)

Erismatura maccoa EYTON, Monagr. Anat., June, 1838, p. 159 ("Indian Isles" [= South Africa]).

Two specimens of this rare duck, both from Crater Lake, are in the collection:

Adult male, March 18, 1930. "Iris dark brown; eyelids pale forgetmenot blue; bill light amparo blue, the tip pale forgetmenot blue, the nostrils and tip edged with flesh color; legs and feet, chaetura drab to mouse gray outside, light olive gray inside."

Adult male, March 19, 1930. Length, 432 mm.

[This duck was common at Crater Lake on March 18. I swam out after 1 of the ducks shot, but about 20 yards beyond the fringe of rushes I encountered soft oozy muck through which it was exceedingly difficult to swim, and on account of which my return to shore was slow and hazardous.—A.B.F.]

Nyroca erythrophthalma (Wied)

Anas erythrophthalma WIED, Beitr. Naturg. Brasil, Vol. IV, 1832, p. 929 (Lagoa do Braço, Villa Belmont, southern Brazil).

Four specimens, all from Crater Lake:

Adult male, March 18, 1930. "Iris carmine, eyelids black; bill burn blue; legs french gray; webs of toes deep neutral gray."

Adult male, March 17, 1930. Length, 495 mm. "Iris light cadmium, with indistinct reddish radial lines to the outer margin; bill pale windsor blue, its edges rosy; front of legs pale russian blue; webs of toes black."

Adult male, March 17, 1930. Length, 489 mm. "Iris scarlet; bill pale russian blue; feet and legs, dark plumbeous."

Adult male, March 18, 1930. Length, 483 mm.

[This was the most numerous duck at Crater Lake on March 18; we saw 100 or more ducks there at that time.—A.B.F.]

Querquedula querquedula (Linnaeus)

[*Anas*] *Querquedula* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 126 ("Europa" [restricted type locality, Sweden]).

Two specimens, from Koroli:

Adult male, April 18, 1930. Length, 405 mm. "Iris brown; bill blackish brown No. 1 at tip, dark grayish brown at base; legs and feet, deep olive gray."

Adult male, April 15, 1930. Length, 394 mm. "Iris hazel; bill dark purplish gray at base, black at tip; legs and feet, dark gull gray."

[At Koroli on April 15 a flock of 20 individuals was discovered on a small pond from which the first specimen above mentioned was taken. Others were observed on April 17 and 18, but were noticed to be very wild.—A.B.F.]

Dendrocygna viduata (Linnaeus)

[*Anas*] *viduata* LINNAEUS, Syst. Nat., Ed. 12, Vol. I, 1766, after May 24, p. 205 ("Carthagenae lacubus" [Colombia]).

Nine specimens, all from Koroli, April 15, 1930:

Adult male. Length, 451 mm. "Iris brown; eyelids dawn gray; bill with terminal band of deep gull gray, the nostrils cinereous; legs and feet, cadet gray touched with black on top of toes and in front of tarsus."

Adult male. Length, 476 mm. "Iris hazel."

Adult male. Length, 457 mm. "Iris dark hazel."

Adult male. Length, 457 mm.

Adult female. Length, 470 mm. "Iris dark hazel."

Adult female. Length, 483 mm. "Iris hazel."

Three adult females. Lengths, respectively, 457, 476, and 483 mm.

[Our specimens were obtained amongst sandhills from small lakes and ponds filled by recent rains. About 20 of these ducks were seen on April 15, usually in pairs.—A.B.F.]

Sarkidiornis melanotos (Pennant)

Anser melanotos PENNANT, Indian Zoöl., 1769, p. 12, pl. XI ("Ceylon").

Five adult males, all from Archer's Post, and collected on March 21, 1930. Lengths, 673, 673, 673, 711, 718 mm.

[The specimens that we obtained were killed near a small puddle in thorn scrub country just north of Archer's Post. When surprised they were resting under the shade of a thorn tree.—A.B.F.]

The generic name *Sarkidiornis* has sometimes been considered as of masculine, sometimes as of feminine, gender. Its terminal element is of common gender, and therefore the original describer should have the privilege of determining its gender. In this case Eyton, who is responsible for the name *Sarkidiornis*, treated it as masculine.

Alopochen aegyptiaca (Linnaeus)

[*Anas*] *ægyptiacus* LINNAEUS, Syst. Nat., Ed. 12, Vol. I, 1766, after May 24, p. 197 ("in Ægypto?").

Six specimens:

Adult unsexed, 21 miles east of Archer's Post, March 5, 1930. Length, 629 mm. "Iris apricot orange; bill livid brown, its knob and tip, and the nostrils, brownish black; legs and feet, pale flesh."

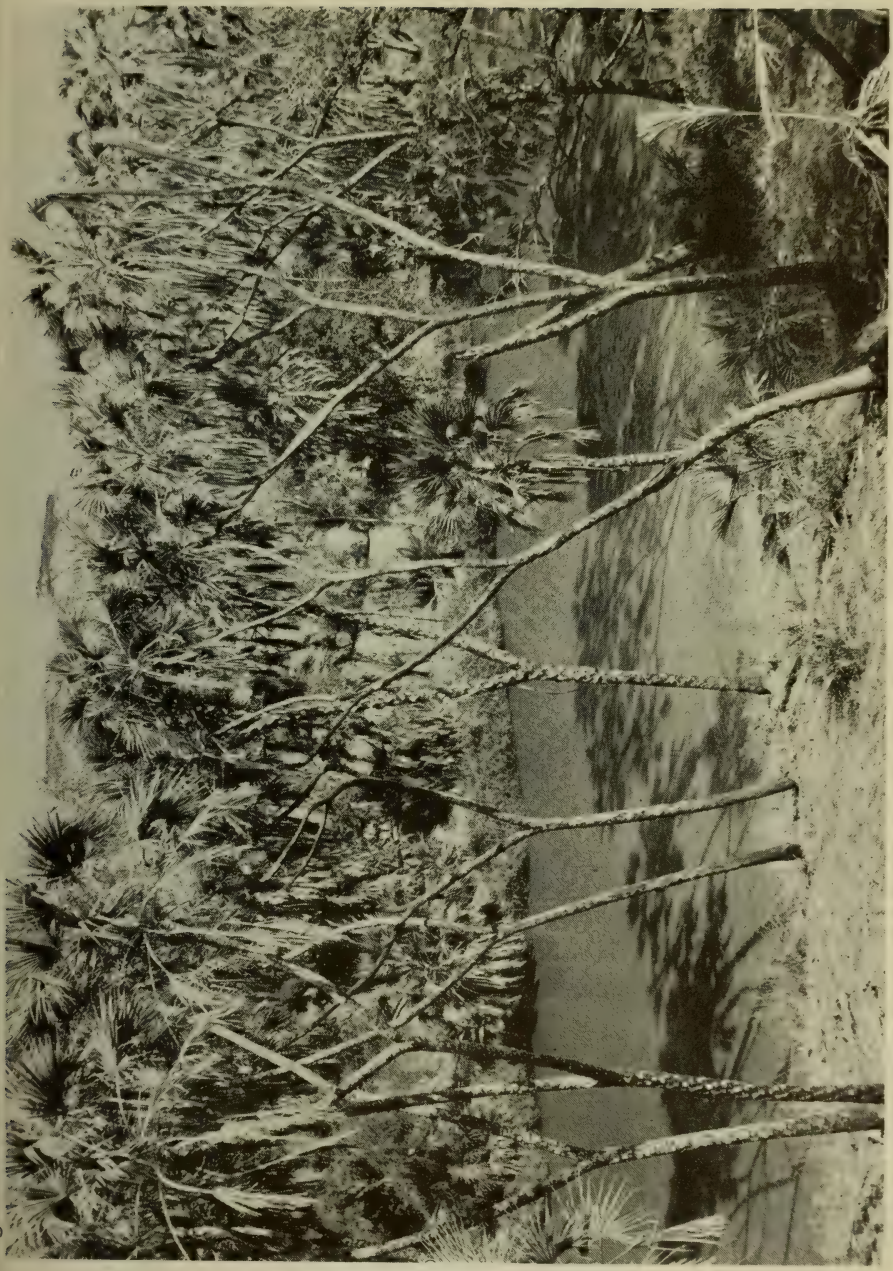
Adult female, Lake Rudolf, April 12, 1930.

Adult male, Koroli, March 24, 1930. Length, 648 mm. "Iris orange; bill tilleul buff, its edges vinaceous lilac, the knob army brown; legs and feet, vinaceous lilac on mottled fleshy white."

Adult male, Koroli, April 15, 1930. Length, 699 mm.

Adult female, Koroli, March 24, 1930. Length, 673 mm. "Iris

Camp of the White-Fuller Expedition on the Northern Uaso Nyiro, opposite (South of) Archer's Post. February 22, 1930.



Dom Palms along the Northern Uaso Nyiro East of Archer's Post, Looking across from the Southern Bank. March 2, 1930.

GUN-BEARER OF ONE OF THE EXPEDITION'S GUIDES AT A TERMITE HILL
NEAR ARCHER'S POST, February 27, 1930

Field. Mus. Pub. C.M.N.H.

light cadmium; bill white, edged with brown and vinaceous, its knob dark brown; legs and feet, pale fleshy white."

Adult female, Koroli, April 15, 1930. Length, 660 mm.

[Occasionally seen on March 5 along the Northern Uaso Nyiro 21 miles east of Archer's Post. At Koroli during the last week of March it was common in pairs along the stream, and much on the wing. At the same locality on April 15 it was still common both along the stream and at small ponds among the sand hills. At Lake Rudolf we noticed a pair with 4 young which were 3 or 4 days old.—A.B.F.]

Family SAGITTARIIDAE

Sagittarius serpentarius gambiensis (Ogilby)

Gyp[*ogeranus*]. *gambiensis* OGILBY, Proc. Zool. Soc. London, Vol. for 1835 [October 9, 1835], p. 105 ("Senegambia").

One adult female, taken at Lasamis, March 14, 1930. Length, 1257 mm.

[Two secretary birds were seen on a small open plain near Archer's Post on March 1.—W.T.W.]

The Northern Secretary Bird is recognized by Bannerman[1], who has made a careful study of its characters. It is the race to be found in Kenya. The typical (nominate) subspecies[2] is from southern Africa.

Family AEGYPIIDAE

Pseudogyps africanus (Salvadori)

Gyps africanus SALVADORI, Not. Stor. R. Accad. Sci. Torino, 1865, p. 133 [Sennar].

One male in the brown immature plumage was collected at Kisima Kufuta on May 14, 1930. Length, 864 mm. "Bill, legs, and feet, black; iris dark brown; skin of face and throat dark neutral gray; neck pale lumiere green with gray spots."

[This vulture was common at Kisima Kufuta from May 6 to 14, though less numerous than the Hooded Vulture.—A.B.F.]

Trigonoceps occipitalis (Burchell)

Vultur occipitalis BURCHELL, Travels Interior Southern Africa, Vol. II, 1824, p. 329 (footnote) ("River Makkwarin" [=Matlowing River], near Kuruman, Bechuanaland).

The only specimen is a female nearly adult but with tawny ochraceous occiput and median upper wing-coverts much tinged with grayish brown and buff. It was collected at Lasamis, March 15, 1930. Length, 806 mm.

[At Kisima Kufuta on May 13 this vulture was common though less numerous there than either the White-backed Griffon or the Hooded Vulture.—A.B.F.]

[1]Birds Tropical West Africa, Vol. I, 1930, pp. 165-169.

[2]*Falco serpentarius* J. F. Miller, Various Subjects Natural History, No. 5, 1779, pl. XXVIII [Cape of Good Hope].

Neophron percnopterus percnopterus (Linnaeus)

[*Vultur*] *Perenopterus* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 87 (" in Ægypto").

A single adult male, obtained at Koroli, March 24, 1930, is the only specimen. Length, 686 mm. "Iris mahogany red; bill deep mouse gray, palest at cutting edges; head between cadmium and light cadmium with small citrine blotches in front of eyes; legs ivory yellow; feet flesh."

[The Egyptian Vulture was not uncommon at Balessa during late March and early April. An occasional individual was observed near our camp on the southeastern shore of Lake Rudolf, April 11 to 13. At Koroli the vultures seemed to know when we were preparing to break camp, for they were on hand ready to move in and to clean up the scraps the instant that we departed.—A.B.F.]

The specific name of this bird is usually written *percnopterus*; but Linnaeus[1] spelled it *Perenopterus*. That this is a typographical error in Linnaeus's Systema Naturae is evident from the fact that the name was spelled *Percnopterus* by both Aldrovandus[2] and Ray[3], though incorrectly quoted by Linnaeus.

Necrosyrtes monachus pileatus (Burchell)

Vultur pileatus BURCHELL, Travels Interior Southern Africa, Vol. II, 1824, p. 195 (footnote) ("Vulture Station" [about 65 miles south of Orange River; that is, in Hopetown district of Cape Province, South Africa]).

Three specimens, from Kisima Kufuta, May 14, 1930:

Adult male. Length, 667 mm. "Legs and feet, pearl gray; basal half of bill, face, and folds of skin on throat, white; rest of bare skin washed with rose purple."

Adult female. Length, 686 mm. "Iris dark brown; legs and feet pale bluish glaucous; base of bill, face, and neck, fleshy white, washed with lilac around eyes and around sides."

Immature male. Length, 711 mm. "Iris dark brown; bill lavender gray, its tip brownish; face and throat, fleshy white with lavender tint around eyes and lower throat; legs and feet, pearl gray."

[This was the most numerous vulture while we were at Kisima Kufuta from May 6 to 14. We made use of this and other vultures for the purpose of cleaning the skeletons of animals that we collected. After removing most of the meat and placing the bones where the vultures would have access to them, the birds would in a few minutes remove every bit of flesh.—A.B.F.]

Family FALCONIDAE

Rhynchodon peregrinus perconfusus (Collin and Hartert)

Falco peregrinus perconfusus COLLIN and HARTERT, Novit. Zool., Vol. XXXIV, No. 1, August 10, 1927, p. 52 (nom. nov. pro *Falco*

[1]Loc. cit.
[2]Ornith., Vol. I,c.10, p. 216.
[3]Syn. Meth. Avium et Piscium, 1713, p. 8.

minor Schlegel, nec Bekker, Borkhausen, and Lichtenhammer [Mountains of the Cape of Good Hope]).

One adult female, Balessa, March 30, 1930. Length, 432 mm. "Cere and bare skin around eyes, lemon chrome; legs and feet, light cadmium."

The peregrine falcons seem to be sufficiently distinct from their closest relatives to be placed in a separate genus, for which the name *Rhynchodon* Nitzsch[1] is available.

Erythropus amurensis (Radde)

Falco vespertinus var. *amurensis* RADDE, Reis. Süden von Ost-Sibir., Vol. II, 1863. p. 102, pl. I, figs. 2a, 2b ("Dseja-Mundung" [=Blagowestschenk on the middle Amur]).

One male, collected at Koroli, March 27, 1930. Length, 279 mm. "Iris brown; bare space in front of eye salmon orange; cere grenadine; legs and feet, flame scarlet."

This specimen is apparently in second nuptial plumage, in which condition it differs from the adult male in having the chin and throat dull white; the gray feathers of jugulum, breast, and upper abdomen with shaft stripes of slate color; the under wing coverts conspicuously barred with brownish slate; and the wing quills dark brown, barred with white on basal portion of inner webs. In this example the outer rectrix is light gray barred with brownish slate; but the tail is in molt.

Cerchneis rupicoloides arthuri (Gurney)

Tinnunculus arthuri GURNEY, List Diurnal Birds Prey, June, 1884, p. 156 ("Mombasa").

One immature female, taken at Koroli, March 25, 1930. Length, 330 mm.

The small falcons closely related to the present species differ trenchantly in structural characters from the other birds commonly referred to the genus *Falco*, and should be generically separated under the name *Cerchneis* Boie.

The genus *Megacerchneis* proposed by Austin Roberts[2] for the present species does not seem separable from *Cerchneis*.

Cerchneis naumanni naumanni (Fleischer)

Falco Naumanni FLEISCHER, in Laurop and Fischer's 'Sylvan' for 1817-1818 (1818), p. 174 (southern Germany).

Eight specimens:

Adult male, Kasut Plain, March 16, 1930. Length, 311 mm. "Iris brown; eyelids and cere, light cadmium; bill cream color, dark at base and slaty black at tip; legs and feet, cadmium yellow."

[1]Obs. Avium Carot. Comm., 1829, p. 20 (type by subsequent designation, *Falco peregrinus* Tunstall).

[2]Ann. Transvaal Mus., Vol. VIII, No. 4, October 30, 1922, p. 211 (in text) (type by original designation, *Falco rupicoloides* Smith).

Adult male, Balessa, March 30, 1930, Windsor T. White. Length, 318 mm.

Two adult females, Balessa, March 30, 1930, Windsor T. White. Lengths, 318 and 330 mm., respectively.

Adult male, Balessa, March 30, 1930. Length, 330 mm. "Iris dark brown; cere, legs, and feet, cadmium yellow."

Adult female, Balessa, March 30, 1930. Length, 330 mm.

Two adult males, Balessa, March 31, 1930. Lengths, 318 and 330 mm.

Cerchneis naumanni pekinensis (Swinhoe)

Falco cenchris var. *pekinensis* SWINHOE, Proc. Zool. Soc. London, Vol. for 1870, No. 3, October 1, 1870, p. 442 ("Changping Chow, twenty five miles from" [Peking,China]) (in text).

Three specimens:

Adult male, Koroli, March 25, 1930. Length, 321 mm.

Adult male, Balessa, March 30, 1930. Length, 318 mm.

Adult female, Balessa, March 30, 1930. Length, 349 mm.

The female of this kestrel differs from the female of *Cerchneis naumanni naumanni* in the somewhat lighter and decidedly less extensive tawny or rufous areas on the wing coverts, the black bars being wider and the tawny interspaces narrower.

Polihiërax semitorquatus castanonotus (Heuglin)

Hypotriorchis castanonotus HEUGLIN, The Ibis, Ser. 1, Vol. II, No. 8, October, 1860, p. 407 ("Méré Belenia, [near Gondokoro, Upper] White Nile").

Two specimens:

Adult female, Merile, April 27, 1930. Length, 185 mm. "Iris hazel; eyelids, cere, legs, and feet, coral red."

Adult female, Archer's Post, May 15, 1930. Length, 190 mm. "Iris brown."

Family ACCIPITRIDAE

Chelictinia riocourii (Vieillot and Oudart)

Elanoïdes riocourii VIEILLOT and OUDART, Gal. Ois., Vol. 1, 1823, p. 43, pl. XVI (Senegal).

Seven specimens, all from Koroli:

Adult male, April 16, 1930. Length, 375 mm. "Iris nopal red; bare skin above eyes, with eyelids and nostrils, ecru olive; legs and feet, between light orange yellow and deep chrome."

Adult male, April 16, 1930. Length, 368 mm. "Iris nopal red; bare skin above eyes, with eyelids and cere, ecru olive; legs and feet, between light orange yellow and deep chrome."

Adult female, April 16, 1930. Length, 375 mm. "Iris nopal red; bare skin above eyes, with eyelids and cere, ecru olive; legs and feet, between light orange yellow and deep chrome."

Adult female, April 17, 1930. Length, 362 mm. "Iris nopal red; eyelids and cere, buffy olive; bill dark neutral gray; legs and feet, between light orange yellow and light cadmium."

Female in second nuptial plumage, April 16, 1930. Length, 254 mm. "Iris nopal red; cere saccardo olive, legs and feet, deep chrome."

Male in first nuptial plumage, April 16, 1930. Length, 330 mm. "Iris light orange yellow; legs and feet, orange buff."

Female juvenile, April 16, 1930. "Iris olive gray; cere and bare skin around eyes, baryta yellow; legs and feet, buff yellow."

The above-listed specimen in second nuptial plumage is like the adult except for the lack of the black patch on the under wing coverts. The male in first nuptial plumage differs from the adult, in addition to the lack of black on the lower wing coverts, also in having buff tips on many of the scapulars and upper wing coverts, and in showing very fine slate-colored shaft lines on the feathers of the breast and jugulum.

The specimen in juvenal plumage likewise lacks any black on the under wing coverts; has broad feather tips of amber brown, cinnamon rufous, tawny, and ochraceous tawny on the back, scapulars, upper wing coverts, and sides of the hind neck; ochraceous buff tips on the tertials; and narrow shaft stripes of brownish slate on the breast and jugulum. The natal down still borne on the tips of the feathers of the pileum is white, and indicates thus that the natal plumage of this species is white.

[At Koroli on April 16 we ran into a flock of these kites from which we secured several specimens. These birds were over an open plain, but they seemed to use as a base a tall thorn thicket from which a group of a dozen or more individuals scattered out to hunt in all directions.—A. B. F.]

Milvus migrans migrans (Boddaert)

Falco migrans BODDAERT, Tabl. Planch. Enlum., 1783, after December 1, p. 28 (based on D'Aubenton, Planch. Enlum. d'Hist. Nat., pl. 472; restricted type locality, France, fide D'Aubenton, pl. 472).

One adult female, Koroli, March 25, 1930. Length, 641 mm.

Milvus migrans parasitus (Daudin)

Falco parasitus DAUDIN, Traité d'Ornith., Vol. II, 1800, p. 150 ("chez les Caffres et les Grands Namaquois" [South Africa]).

Three specimens:

Adult male, Lasamis, March 13, 1930. Length, 514 mm. "Iris brown; bill, legs, and feet, yellow."

Adult male, Lasamis, March 14, 1930. Length, 508 mm.

Adult male, Archer's Post, February 27, 1930, P. R. Runton. Length, 524 mm. "Bill colonial buff; cere and legs, apricot yellow."

The second of these individuals has the terminal portion of the bill dark brown, but is nevertheless apparently adult.

[This kite was numerous around our base camp at Archer's Post on February 25. A few were noted sailing about overhead at Crater Lake on March 18; and it was occasionally seen at Lake Rudolf on April 12. On the way from Balessa to Mount Kulal it was now and then noticed on April 1; at Koroli individuals were present on March 27, and on March 28 several individuals were hovering and wheeling above our heads as we were breaking camp there.—A. B. F.]

Aquila rapax raptor Brehm

Aquila raptor A. E. BREHM, Naumannia, Vol. [V], No. 1, 1855, p. 13 ("am blauen und weissen Flusse" [=Blue and White Nile]).

Three specimens:

Adult male, Koroli, March 26, 1930. Length, 679 mm. "Iris cream color, with indistinct sepia bars and radial lines; skin above eyes pale mouse gray; eyelids sepia; bill black at tip changing to light dull gray at cere; cere and gape, cream color; legs and feet, cream color."

Immature female, Koroli, March 27, 1930. Length, 692 mm. "Iris chamois, indistinctly clouded with sepia; skin above eyes yellowish citrine; bill light olive gray at base, black at tip; cere and gape, light cadmium; feet buff yellow."

Immature female, Balessa, March 30, 1930. Length, 686 mm. "Iris maize yellow, clouded with blister; cere and feet, maize yellow."

These, like other Kenya birds, are, though somewhat intermediate, nearer *Aquila rapax raptor* than to *Aquila rapax rapax* of South Africa, to which the Kenya birds have by some authors been referred. As a matter of fact, examples from Lake Manyara, Tanganyika, are also apparently to be referred to *Aquila rapax raptor*.

[The bird obtained at Koroli on March 27 was, when I first saw it, sitting on the top of a small thorn bush. It alighted on the ground and was catching the locusts that later were found in its crop.—A. B. F.]

Polemaëtus bellicosus (Daudin)

Falco bellicosus DAUDIN, Traité d'Ornith., Vol. II, 1800, p. 38 ("pays des Grands Namaquois, entre le 28° Sud et le Tropique" [=Great Namaqualand, between latitude 28° south and the Tropic of Capricorn]).

Two specimens of this rare eagle were obtained by the expedition:

Adult male, Lasamis, March 14, 1930.

Immature male, Kisima Kufuta, May 10, 1930. Length, 761 mm.

Circaëtus pectoralis A. Smith

Circætus pectoralis A. SMITH, South Afr. Quart Journ., Ser. 1, No. 2, March, 1830, p. 109 ("South Africa").

One specimen, an adult male, captured at Lasamis on March 14, 1930. Length, 651 mm. "Iris cadmium yellow, its outer edge black; eyelids and tip of beak, black; bare skin above eyes dutch blue; base of bill sky gray; feet and legs, pearl gray."

Accipiter badius sphenurus (Rüppell)

Falco (*Nisus*) *sphenurus* RÜPPELL, Neue Wirbelth. Fauna Abyss. Vögel, Lief. 183, 1836, p. 42 ("Dahalak Id., bei Messana" [Red Sea]).

Two specimens, from Balessa, taken on March 30, 1930:

Adult male. Length, 305 mm. "Iris grenadine red; cere, legs, and feet, cadmium yellow."

Adult female. Length, 337 mm. "Iris grenadine red; cere, legs, and feet, cadmium yellow."

The genus *Astur* Lacépède is sometimes merged with *Accipiter* Brisson, and it seems properly so, since there seem to be, when all the species are considered, no trenchant structural characters separating the two groups.

Meliërax poliopterus Cabanis

Melierax poliopterus CABANIS, Journ. f. Ornith., Vol. XVI, No. 6, November, 1868, p. 413 ("Ost-Afrika" [=Umba River on the Kenya-Tanganyika boundary]).

Nine specimens:

Adult female, Kisima Kufuta, May 9, 1930. Length, 512 mm. "Iris claret brown; cere cadmium yellow; legs and feet, bittersweet orange."

Adult female, Kisima Kufuta, May 12, 1930. Length, 553 mm. "Iris chestnut brown; cere light cadmium; legs and feet, cadmium orange."

Adult male, Kisima Kufuta, May 14, 1930.

Adult male, Koroli, April 18, 1930. Length, 514 mm.

Adult male, Balessa, March 30, 1930. Length, 508 mm. "Iris carmine; cere cadmium yellow; legs bittersweet orange."

Adult male, Archer's Post, February 28, 1930. Length, 470 mm.

Adult male, Archer's Post, May 15, 1930. Length, 512 mm.

Adult male, Archer's Post, May 16, 1930. Length, 483 mm.

Adult female, Kinya, May 4, 1930. Length, 522 mm. "Cere light cadmium; legs and feet, bittersweet orange."

All these birds show some molt on the upper parts, and the individual from Archer's Post, taken on May 16, is molting also some of the wing quills.

In case the genus *Micronisus* Gray is considered inseparable from *Meliërax*, the former name should be used for the combined group as explained under *Micronisus gabar*. When both genera are recognized the generic name for the present species is of course *Meliërax*.

Micronisus gabar (Daudin)

Falco gabar DAUDIN, Traité d'Ornith., Vol. II, 1800, p. 87 ("près des rivières Swart-Kop et Sondag; Camdeboo; entre les montagnes de Neige et le Bock-Veld" [type locality restricted to Swart-Kop River, Cape Colony, by Oberholser[1]]).

[1]Proc. U. S. Nat. Mus., Vol. XXVIII, No. 1411, July 8, 1905, p. 829.

Three specimens:

Immature (first nuptial?) male, Kisima Kufuta, May 9, 1930. Length, 351 mm. "Iris lemon yellow; cere sulphine yellow; legs and feet, capucine yellow."

Immature (first nuptial?) female, Archer's Post, February 25, 1930. Length, 337 mm.

Immature (first nuptial?) unsexed, Archer's Post, February 26, 1930.

This small hawk is sometimes referred to the genus *Meliërax*, but it differs from the latter group in so many important particulars of structure that it should be separated in a genus of its own. From *Meliërax musicus* and *Meliërax poliopterus*, *Micronisus gabar* differs as follows:

Folded wings not reaching to middle of tail, instead of much beyond: 4, instead of 5, primaries sinuate on inner webs; length of middle toe without claw much more than one-half of tarsus, instead of much less; claw of inner toe not reaching to the base of middle claw, instead of farther; cere small, occupying less than one-third of culmen, instead of almost one-half; nostril round instead of more or less elliptical and oblique; and anterior edge of nostril situated only one-third of the length of bill from base instead of almost one-half.

The generic name *Micronisus* was first proposed by Gray[1], and its monotypic type designated as *Falco gabar* Shaw (=Daudin). On the same page Gray introduced also the generic name *Meliërax* for *Falco musicus* Daudin. Some authors have united these 2 genera, and have apparently invariably used the name *Meliërax* for the combination. However, *Micronisus* stands first on the page, and since it thus has anteriority, should be the name for the combination if only 1 genus be recognized. The characters above given, however, indicate the desirability of separating *Micronisus* from *Meliërax*.

Circus pygargus (Linnaeus)

[*Falco*] *Pygargus* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 89 ("Europa" [restricted type locality, England]).

Seven specimens, all from Archer's Post:

Adult male, March 6, 1930. Length, 441 mm.

Adult male, March 6, 1930. Length, 406 mm.

Adult male, March 7, 1930. Length, 451 mm.

Two immature males, March 6, 1930. Lengths, respectively, 429 and 457 mm.

Adult female, March 6, 1930. Length, 429 mm.

Immature female, March 6, 1930. Length 432 mm. Of all these individuals, adult as well as immature, the unfeathered parts were described as alike: "iris primuline yellow; legs and feet, cadmium yellow."

[1]List Genera Birds, 1840. p. 5.

Circus macrourus (Gmelin)

Accipiter macrourus S. G. GMELIN, Nov. Comm. Acad. Sci. Imp. Petrop., Vol. XV, 1771, p. 439, pls. VIII-IX ("Woronetz adhinc ad omnem Tenain" [=Veronetz Gouvernment to the Volga River]).

One immature (first nuptial?) specimen, from Koroli, collected on April 16, 1930. Length, 470 mm. "Iris light cadmium; eyelids and cere, wax yellow; legs and feet, apricot yellow."

Family PERDICIDAE

Coturnix delegorguei delegorguei Delegorgue

Coturnix Delegorguei DELEGORGUE, Voy. Afr. Austr., Vol. II, 1847, p. 615 ("River Oury" [=Oury, upper Limpopo River, Transvaal]).

Two specimens:

Adult male, Koroli, April 17, 1930. Length 170 mm. "Iris brown; bill black; legs and feet, cinnamon buff."

Immature male (probably in first nuptial plumage), Lasamis, March 13, 1930, Windsor T. White.

The latter bird is decidedly paler both above and below than is the adult male. The black area on the breast is less extensive and more brownish; and the dark patch on the throat is fuscous mixed with pale buff, instead of being wholly black.

[This species was fairly common at Koroli, April 16-18.—A.B.F.]

Family PHASIANIDAE

Francolinus africanus uluensis Ogilvie-Grant

Francolinus uluensis OGILVIE-GRANT, The Ibis, Ser. 6, Vol. IV, No. 1, January, 1892, p. 44 ("Machakos, in the Ulu country" [British East Africa=Kenya]).

Seven specimens:

Adult male, Gunga Lake, May 20, 1930. Length, 350 mm.
Adult male, Gunga Lake, May 20, 1930. Length, 348 mm.
Adult male, Gunga Lake, May 20, 1930. Length, 324 mm.
Adult male, Gunga Lake, May 20, 1930. Length, 338 mm.
Adult female, Gunga Lake, May 20, 1930. Length, 341 mm.

Adult female, Mount Kulal, altitude, 6000 feet, April 5, 1930. Length, 343 mm. "Iris brown; legs and feet, light pinkish cinnamon, washed with pinkish buff."

Adult female, 20 miles west of Meru, May 18, 1930. Length, 348 mm. "Iris hazel."

The above mentioned female from Mount Kulal was secured on a grassy slope, under tall cedars. Another adult and 2 young about two-thirds grown were flushed at the same time.

The specimen taken at this locality had swollen ovaries but no sizable ova. The crop was crammed with millipeds, locusts, spiders, spider egg sacs, large ants, and a praying mantis.

[In flight this species resembles the North American Ruffed Grouse (*Bonasa umbellus*) more than any other bird that I have flushed in Africa.—A. B. F.]

[Along Isiolo Creek, 3 of these francolins were obtained on February 25, and 3 others on February 28.—W.T.W.]

Francolinus squamatus kapitensis Mearns

Francolinus schuetti kapitensis MEARNS, Smiths. Misc. Coll., Vol. LVI, No. 14, December 23, 1910, p. 1 ("Juja Farm, near the Athi River, British East Africa, altitude about 4200 feet").

Three specimens, from Gunga Lake near Meru:

Adult male, May 20, 1930. Length, 365 mm. "Iris hazel; bill peach red; legs and feet, grenadine."

Adult female, May 25, 1930. Length, 327 mm.

Female in first winter plumage, May 24, 1930. Length, 302 mm. "Iris dark brown; legs and feet, bittersweet orange."

Doctor Friedmann is apparently correct in uniting *Francolinus squamatus keniensis*[1] Mearns with *Francolinus squamatus kapitensis* (which latter name has anteriority), since such differences as are observable seem to be due to individual variation, and are thus not constant enough for the recognition of the Kenya race.

On the other hand, *Francolinus squamatus kapitensis* differs from *Francolinus squamatus maranensis*[2] in its more uniform, somewhat more grayish or sooty (less rufescent) upper parts; and particularly in the much wider, less sharply defined edgings of the feathers of the lower surface.

The first winter female above listed differs from the juvenal plumage chiefly in having the superciliary region dull grayish brown instead of buff, the upper and lower surfaces lighter, more streaked, instead of barred with black, buff, and dull gray.

Pternistis leucoscepus keniensis (Mearns)

Pternistes leucoscepus keniensis MEARNS, Smiths. Misc. Coll., Vol. LVI, No. 20, April 17, 1911, p. 1 ("west slope of Mount Kenya on the Njoro or Kasorongai River, 6500 feet, British Africa").

Eleven specimens, from Archer's Post:

Three adult males, February 28, 1930, Windsor T. White. Lengths, 394, 419, and 432 mm.

One adult male, February 28, 1930. Length, 419 mm. "Iris hazel brown."

Two adult males, February 25, 1930. Lengths, 400 and 419 mm.

One adult female, February 28, 1930. Length, 349 mm.

Two adult females, February 25, 1930. Lengths, 375 and 375 mm.

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[1] *Francolinus schuetti keniensis*, ibid. ("Nyeri [altitude 5943 feet] base of Mount Kenia, British East Africa").

[2] *Francolinus schuetti maranensis* Mearns, ibid., p. 1 ("Maranu, Mount Kilimanjaro, German East Africa, altitude 5000 feet").

One unsexed (probably female), February 25, 1930. Length, 375 mm.

One unsexed (probably female), February 28, 1930.

This series apparently substantiates the distinctness of *Pternistis leucoscepus keniensis* as compared to *Pternistis leucoscepus infuscatus*.

[Two were shot at Lasamis on April 25, and another on March 21.—W.T.W.]

[One was taken on February 28 in the tall grass on the banks of the Northern Uaso Nyiro near Archer's Post. The birds above listed as collected on February 25 were obtained from dry grass tussocks about knee high near a small stream with grassy banks winding through the scrub not far from Archer's Post.—A.B.F.]

Family NUMIDIDAE

Numida meleagris macroceras Erlanger

Numida ptilorhyncha macroceras ERLANGER, Ornith. Monatsb., Vol. XII, No. 6, June, 1904, p. 97 ("Fluss Muki. Seengebiet" [=Muki River, Lake Rudolf]).

Two specimens, from 20 miles west of Meru:

Adult female, May 18, 1930. Length, 551 mm. "Iris dark brown."

Female, "subadult" (probably second nuptial plumage), May 18, 1930. Length, 531 mm.

Acryllium vulturinum (Hardwicke)

Numida vulturina HARDWICKE, Proc. Zool. Soc. London, Vol. II, September 26, 1834, p. 52 ("Western coast of Africa" [errore; designated by Friedmann[1] as Tsavo, Kenya Colony]).

Five specimens:

Adult male, Archer's Post, February 28, 1930, George Runton. Length, 727 mm. "Iris nopal red; bill paris green at base, paler at tip; head and neck, slate gray."

Adult male, Archer's Post, February 29, 1930. Length, 651 mm. "Iris nopal red."

Adult female, Archer's Post, February 28, 1930. Length, 727 mm. "Iris nopal red."

Adult male, Balessa, March 30, 1930. Length, 787 mm.

Adult female, Balessa, March 24, 1930. Length, 692 mm.

[At Lasamis birds of this species were shot on March 13, April 24 and 25; at Koroli on March 26; and at Balessa on March 29. During our trip by automobile to Maddo Gashi over some 125 miles of distance east from Archer's Post we several times stopped to hunt Vulturine Guineafowls.—W.T.W.]

[1]Bull. U. S. Nat. Mus., No. 153, Part 1, June 10, 1930, p. 136.

Family RALLIDAE

Fulica cristata Gmelin

[*Fulica*] *cristata* GMELIN, Syst. Nat., Vol. I, Part ii, April, 1789, p. 704 ("Madagascar").

Five specimens, from Crater Lake:

Adult female, March 17, 1930. Length, 425 mm. "Iris nopal red; frontal shield white, its caruncles burnt umber; bill sky gray; legs and feet, pale russian blue, faintly washed with yellow-green on sides of tarsus; patch above tibio-tarsal joint light yellow-green touched with english red."

Adult female, March 18, 1930. Length, 406 mm. "Iris carmine; frontal shield white, its caruncles chestnut; bill sky gray; legs and feet, pallid neutral gray, darkening at joints to deep neutral gray."

Adult male, March 18, 1930. Length, 406 mm.

Adult female, March 18, 1930. Length, 445 mm.

Adult female, March 19, 1930. Length, 413 mm.

[There were in Crater Lake on March 18 many European Coots, whose croaking notes could be heard continually from among the rushes and weeds along the border.—A.B.F.]

Family GRUIDAE

Balearica pavonina gibbericeps Reichenow

Balearica gibbericeps REICHENOW, Journ. f. Ornith., Vol. XL, No. 1, January, 1892, p. 126 ("Deutsch-Ostafrika" [=Lake Jipe]).

One adult, from Archer's Post, collected, March 7, 1930. Length, 1029 mm. "Iris pale russian blue; cheek patch white, its upper edge and the lappets maroon; bill, legs, and feet, black."

[A flock of 42 individuals was met with on Cole's Plains, an open grassy area in grassy thorn scrub, south of Isiolo, on February 23. —W.T.W.]

Family OTIDIDAE

Choriotis kori struthiunculus (Neumann)

Otis kori struthiunculus NEUMANN, Journ. f. Ornith., Vol. LV, No. 2, April, 1907, p. 306 ("Zuai-See" [=Lake Zwai, Ethiopia]).

Two specimens:

Adult female, Archer's Post, February 28, 1930. Length, 1181 mm.; extent of wings, 2248 mm.; weight, 8164 grams. "Iris antimony yellow, with a brownish tinge on inner margin; eyelids black, skin back of eyelids light drab; skin around eyelids ecru drab; lower mandible nearly white; lower edge of nostril and tip of upper mandible, slaty; legs ivory yellow."

Adult unsexed, Kasut Plain, altitude 1700 feet, March 20, 1930. Length, 1283 mm.; diameter of eye, 19 mm.; weight, 17236 grams. "Iris cream buff and honey yellow, lightest above; eyelids white; skin back of eye and below, smoke gray; upper mandible smoke gray; nostril and lower mandible, white; legs and feet, between ivory yellow and colonial buff."

[One of these bustards was seen near Archer's Post on March 1.—W.T.W.]

[Between Balessa and Mount Kulal on April 1, occasional individuals were noted.—A.B.F.]

Eupodotis canicollis somaliensis (Erlanger)

Otis canicollis somaliensis ERLANGER, Journ. f. Ornith.,Vol. LIII, No. 1, January, 1905, p. 82 ("Metaker, Ennia-Gallaland").

Two specimens, from Archer's Post, February 26, 1930.

Adult male. Length, 540 mm.

Adult female. Length, 533 mm.

[Individuals of this bustard were taken between Isiolo and Archer's Post on February 24; Isiolo Creek on February 25; at Lasamis on March 21 and April 24; and at Balessa on March 30 —W.T.W.]

[Between Balessa and Mount Kulal occasional individuals were noted on April 1. Four were observed on February 25 south of camp near Archer's Post in a thorn scrub country with very little grass.—A.B.F.]

The female of this species above listed differs from the male in substantially the same manner as indicated by Friedmann[1].

Lophotis ruficrista gindiana (Oustalet)

Eupodotis Gindiana OUSTALET, Bull. Soc. Philom., Paris, Ser. 7, Vol. V, No. 4, 1881, p. 164 (in text) (East Africa between Somaliland and Zanzibar; type locality, Zanzibar).

Four specimens:

Adult male, Koroli, March 24, 1930, Windsor T. White. "Iris straw yellow; eyelids deep olive buff; lower mandible and base of upper mandible, pearl gray; legs and feet, massicot yellow."

Adult male, Koroli, March 25, 1930. Length, 470 mm.

Adult female, Kisima Kufuta, May 13, 1930. Length, 482 mm. "Iris straw; legs and feet pearl gray."

Adult female, Kinya, May 2, 1930. Length, 470 mm.

Family SCOLOPACIDAE

Capella gallinago gallinago (Linnaeus)

[*Scolopax*] *Gallinago* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 147 ("Europa" [restricted type locality, Sweden]).

Two specimens, from Archer's Post, February 24, 1930:

Adult female. Length 273 mm. "Legs deep olive."

Adult unsexed, probably female. Length, 272 mm. "Legs citrine drab."

[The specimens above listed were obtained in a marsh of cattails and rushes near our camp at Archer's Post.—A.B.F.]

[1]Bull. U. S. Nat. Mus., No. 153, Part 1, June 10, 1930, p. 147.

Rostratula benghalensis benghalensis (Linnaeus)

[*Rallus*] *benghalensis* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 153 ("Asia" [type locality now by the present writer restricted to Bengal, India]).

Two specimens, from Koroli:

Adult male, April 15, 1930. Length, 241 mm. "Iris olive brown; bill hair brown at base to dark vinaceous brown at tip; legs and feet, tea green."

Adult male, April 18, 1930. Length, 247 mm. "Iris brown; bill olive brown at base, chestnut brown on terminal half; legs and feet, grayish olive."

Pisobia minuta (Leisler)

Tringa minuta LEISLER, Nachtr. Bechsteins Naturg. Deutschl., Part I, 1812, p. 74 (Hanau, Germany).

Two specimens:

Adult female, 21 miles east of Archer's Post, March 5, 1930. Length, 152 mm. "Bill, legs, and feet, iron gray."

Adult male, Archer's Post, March 5, 1930. Length, 124 mm.

Actitis hypoleuca (Linnaeus)

[*Tringa*] *Hypoleucos* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 149 ("Europa" [restricted type locality, Sweden]).

Three specimens:

Adult female, Lake Rudolf, April 12, 1930.

Adult female, Lake Rudolf, April 13, 1930.

Adult female, Lasamis, March 22, 1930, collected by Windsor T. White. Length, 205 mm.

[Fairly common along the rock and pebbly beaches of Lake Rudolf on April 11.—A.B.F.]

Tringa ocrophus Linnaeus

[*Tringa*] *Ocrophus* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 149 ("Europa" [restricted type locality, Sweden]).

One adult female, from Crater Lake, March 19, 1930. Length, 248 mm.

[This species was seen also at Koroli on April 15.—A.B.F.]

The specific name of this bird has been often emended to *ochropus*, on the assumption that Linnaeus's original spelling of *ocrophus* was a typographical error. He however spelled it with a capital letter, thus indicating that he regarded the word as a noun, which he evidently took from Gesner and Aldrovandus, as the following citation he gives[1] indicates:

"Rhodolphus s. Ocrophus. Gesn. av. 508. 511. Aldr. orn. 1. 20, c. 39."

This shows that the original spelling *Tringa ocrophus* should be preserved.

[1]Loc. cit.

Iliornis stagnatilis (Bechstein)

T[otanus]. stagnatilis BECHSTEIN, Ornith. Taschenb. Deutschl., Part II, 1803, p. 292 (Germany).

Two specimens:

Adult female, Koroli, April 18, 1930. Length, 264 mm. "Iris dark brown; bill black, the base yellowish olive; legs and feet, buffy olive, touched with isabella color."

Immature female, Archer's Post, March 5, 1930. Length, 235 mm.

[Four were encountered along the shore of Lake Rudolf on April 11; and a flock of 70 at Koroli on April 15. All were wary. —A.B.F.]

Rhyacophilus glareola (Linnaeus)

[*Tringa*] *Glareola* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 149 ("Europa" [restricted type locality, Sweden]).

Four specimens:

Adult female, Archer's Post, March 5, 1930. Length, 222 mm. "Bill with basal third buffy citrine, and the tip black; legs and feet, buffy citrine."

Adult female, Archer's Post, March 5, 1930. Length, 159 mm.

Adult female, Archer's Post, March 5, 1930. Length, 216 mm. "Iris brown; legs olive buff."

Adult female, Kasut Plain, March 20, 1930. Length, 215 mm. "Bill black at tip, citrine at base; legs and feet, citrine."

Family CHARADRIIDAE

Leucopolius varius varius (Vieillot)

Charadrius varius VIEILLOT, Nouv. Dict. d'Hist. Nat., Vol. XXVII, 1818, p. 143 ("Afrique" [type locality now by the present writer restricted to Cape of Good Hope]).

Five specimens:

Adult female, Lake Rudolf, April 13, 1930. Length, 159 mm. "Iris dark hazel; eyelids dark slate; bill black; legs light gray."

Two adult males, from Lake Rudolf, April 13, 1930. Length, 158 and 158 mm., respectively.

Adult male, Koroli, April 8, 1930. Length, 160 mm. "Iris dark brown; eyelids and bill, black; tarsus quaker drab; tibia and feet, dark quaker drab."

Adult female, Koroli, April 18, 1930. Length, 162 mm. Colors of unfeathered parts same as preceding male.

[Occasionally noticed along the shore of Lake Rudolf, on April 10 and 11.—A.B.F.]

For the change of name from *Leucopolius pecuarius* to *Leucopolius varius* see Friedmann's recent explanation[1].

[1]Bull. U. S. Nat. Mus., No. 153, Part 1, June 10, 1930, p. 159.

Afroxyechus tricollaris tricollaris (Vieillot)

Charadrius tricollaris VIEILLOT, Nouv. Dict. d'Hist. Nat., Vol. XXVII, 1818, p. 147 ("Afrique" [restricted type locality, Cape Town]).

Four specimens:

Two adults, male and female, from Archer's Post, taken, March 5, 1930. Length, male, 151 mm., female, 152 mm. "Iris light brown; eyelids scarlet; basal half of bill dark vinaceous; legs and feet, vinaceous fawn."

Adult female, Lasamis, March 22, 1930. Length, 165 mm. "Iris golden brown."

Adult male, Lasamis, March 22, 1930. Length, 165 mm. "Iris golden brown."

The last example shows indication of molt among the contour feathers.

Stephanibyx coronatus coronatus (Boddaert)

Charadrius Coronatus BODDAERT, Tabl. Planch. Enlum., 1783, after December 1, p. 49 (based on D'Aubenton, Planch. Enlum., pl. 800; Cape of Good Hope).

Fourteen specimens:

Adult male, Archer's Post, February 26, 1930. Length, 305 mm. "Bill scarlet, tipped with black; legs scarlet."

Two adult females, Archer's Post, February 26, 1930. Lengths, 305 mm. and 311 mm.

Juvenal male, Archer's Post, February 28, 1930. Length, 241 mm. "Iris yellow; bill scarlet, tipped with black; legs scarlet."

Juvenal female, Archer's Post, February 28, 1930. Length, 297 mm. "Iris yellow; bill scarlet, tipped with black; legs scarlet."

Adult female, Kisima Kufuta, May 8, 1930. Length, 305 mm. "Iris light cadmium; basal half of bill eugenia red, with the tip black; legs and feet, jasper red."

Two adult females, Kisima Kufuta, May 12, 1930. Lengths, 292 mm. and 296 mm. respectively.

Adult male, Kisima Kufuta, May 8, 1930. Length, 312 mm. "Iris light cadmium; basal half of bill eugenia red, the tip black; legs and feet, jasper red."

Two adult males, Kisima Kufuta, May 12, 1930. Lengths, 295 mm. and 303 mm. respectively.

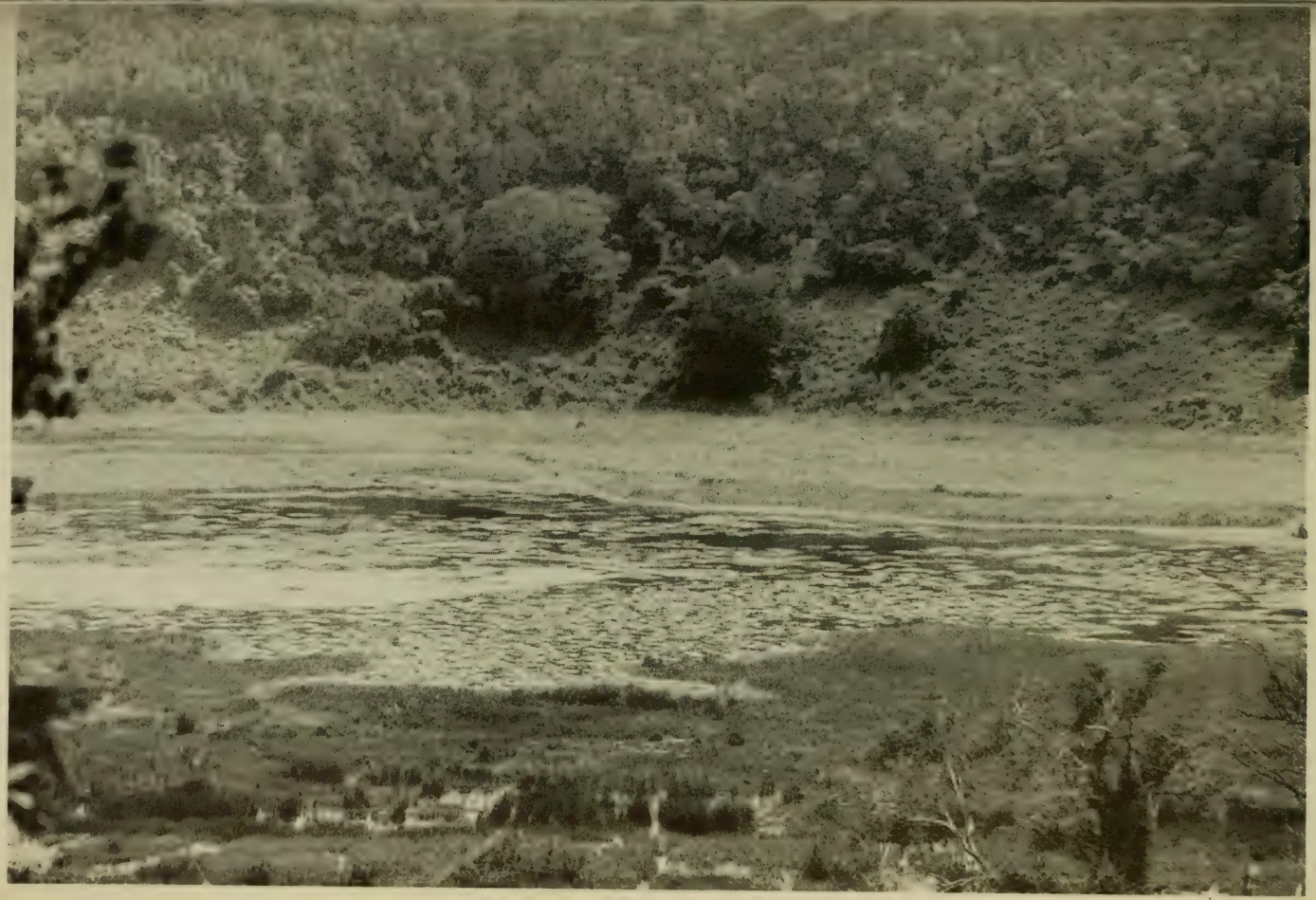
Adult male, Koroli, March 25, 1930. Length, 302 mm. "Iris lemon yellow; base of bill, also legs and feet, jasper red."

Adult male, Lasamis, March 13, 1930. Length, 292 mm. "Iris empire yellow; basal half of bill, also legs and feet, eugenia red."

Juvenal male, Lasamis, March 13, 1930. Length, 219 mm. "Iris sayal brown; bill buff pink, tipped with black; legs and feet, buff pink."

All the birds from Kisima Kufuta are in process of molt so far as the contour feathers are concerned. The two juvenal examples

Boran Watering Place at Bisanada, East of Garba Tula. March 20, 1930.



GUNGA LAKE, LOOKING NORTH TO ITS CRATER. May 20, 1930.

Crater Lake, Looking East from Martin Johnson's Camp. March 16, 1930.

Mount Kulal (in center) Looking Northwest from Balessa. May 8, 1930.

from Archer's Post are molting into the first nuptial plumage. The juvenile from Lasamis is not yet full grown and is molting from the natal into the juvenal plumage in which the dark feathers of the upper surface including the wings have buff or ochraceous buff edgings.

Hoplopterus spinosus (Linnaeus)

[*Charadrius*] *spinosus* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 151 ("in Ægypto").

Five specimens:

Adult male, Archer's Post, February 28, 1930. Length, 265 mm. "Iris nopal red; legs and feet, black."

Adult unsexed, Archer's Post, May, 1930.

Adult male, Koroli, March 24, 1930. Length, 287 mm. "Iris carmine; bill and feet, black."

Adult female, Koroli, March 24, 1930. Length, 280 mm.

Adult male, Lake Rudolf, April 11, 1930. Length, 305 mm.

All these are in process of molting the contour feathers.

[Several Spur-winged Plovers were observed at Archer's Post. One of these disputed our right to pitch camp there, and noisily voiced its prior claim to the territory.—A. B. F.]

Family RECURVIROSTRIDAE

Himantopus himantopus himantopus (Linnaeus)

[*Charadrius*] *Himantopus* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 151 ("Europa australiore" [restricted type locality, southern Italy]).

Five specimens:

Adult male, Archer's Post, March 5, 1930. Length, 337 mm. "Iris carmine; legs and feet, alizarine pink."

Adult male, Koroli, April 18, 1930. Length, 372 mm. "Iris scarlet; eyelids and bill, black; legs and feet, alizarine pink."

Adult male, Koroli, April 15, 1930. Length, 387 mm. "Iris carmine."

Adult female, Koroli, April 15, 1930. Length, 362 mm. "Iris scarlet."

Adult female, Koroli, April 18, 1930. Length, 377 mm. "Iris nopal red; bill black; legs and feet, old rose and alizarine pink."

[At Koroli stilts were in nearly all the suitable ponds. We saw one flock of about a dozen on April 15, and another of about 15 on April 18.—A. B. F.]

Family CURSORIIDAE

Cursorius cursor meruensis Mearns

Cursorius gallicus meruensis MEARNS, Smiths. Misc. Coll., Vol. LXV, No. 13, November 26, 1915, p. 5 ("plains by the Meru River, northern base of Mount Kenia, British East Africa").

Two specimens, adult male and female, from Lasamis, collected, March 14, 1930:

Adult male, length, 203 mm.

The present race, though not recognized by some recent authors, is apparently valid, being of darker coloration than *Cursorius cursor littoralis*, which latter by the separation of *C. c. meruensis* is in Kenya confined in general to the coastal region.

Rhinoptilus cinctus cinctus (Heuglin)

Hemerodromus cinctus HEUGLIN, The Ibis, Ser. 1, Vol. V, No. 1, January, 1863, p. 31, pl. I ("near Gondokoro, on the White Nile, in the Bari country, in 5° N. lat" [British Equatorial Africa]).

Three specimens:

Adult female, Kisima Kufuta, May 6, 1930. Length, 248 mm. "Iris brown; base of bill sulphine yellow; legs and feet, ivory yellow, the latter washed with olive."

Adult female, Kisima Kufuta, May 10, 1930. Length, 262 mm.

Adult female, Kinya, May 1, 1930. Length 238 mm. "Iris brown; basal half of bill olive yellow; legs and feet, cream buff."

This species belongs clearly to the genus *Rhinoptilus*[1] the type of which is by subsequent designation *Cursorius chalcopterus* Temminck.

On the other hand, the species commonly known as *Rhinoptilus africanus* is generically different from *Rhinoptilus chalcopterus*, and has been formally separated by Austin Roberts under the name *Smutsornis*[2]. It differs from *Rhinoptilus* as follows: bill small, much less in length than the middle toe without claw, instead of equal or greater; angle of the gonys scarcely appreciable instead of prominent, the gonys therefore forming nearly a straight line with the lower edge of the rami instead of decidedly ascending; nostrils linear instead of oblong or oblong oval; tail even or a little emarginate, less than one-half the length of wing and but slightly longer than the tarsus, instead of being rounded, at least half as long as the wing, and much longer than the tarsus.

The only species belonging to this genus should therefore be called *Smutsornis africanus*, of which eight subspecies appear to be recognizable.

Smutsornis africanus africanus (Temminck).

Smutsornis africanus sharpei (Erlanger).

Smutsornis africanus granti (W. L. Sclater).

Smutsornis africanus bisignatus (Hartlaub).

Smutsornis africanus illustris (Friedmann).

Smutsornis africanus gracilis (Fischer and Reichenow).

Smutsornis africanus hartingi (Sharpe).

Smutsornis africanus raffertyi (Mearns).

[1]Strickland, Proc. Zool. Soc. London, Vol. XVIII, for 1850 [January 24, 1852], p. 220.

[2]Ann. Transvaal Mus., Vol. VIII, Part 4, October 30, 1922, p. 202 (type by original designation, *Cursorius africanus* Temminck).

Family BURHINIDAE

Burhinus capensis capensis (Lichtenstein)

O[edicnemus]. capensis LICHTENSTEIN, Verz. Doubl., 1823, after August, p.69 ("Cap.b.sp." [=Cape of Good Hope]).

Five specimens:

Adult male, Lasamis, altitude 2090 feet, March 13, 1930. Length, 410 mm. "Iris barium yellow, the outer third with sepia hair-like lines; basal part of bill amber yellow; legs and feet, mustard yellow."

Adult male, Lasamis, April 23, 1930.

Adult female, Lasamis, April 23, 1930.

Adult male, Kinya, March 11, 1930, Windsor T. White. Length, 406 mm.

Adult female, Koroli, April 15, 1930. Length 445 mm. "Iris apricot yellow; eyelids sepia edged with empire yellow; base of bill empire yellow; legs and feet, empire yellow, washed with brownish olive."

The above-catalogued bird from Koroli apparently shows intergradation with the more northern race *Burhinus capensis affinis*, but it is apparently nearer *Burhinus capensis capensis*, although the former occurs at Hor in the northern part of Kenya Colony[1].

Although the generic name *Oedicnemus* has been long in use for this and a number of allied species, the group apparently does not present any trenchant generic characters to separate it from the Australian *Burhinus magnirostris*, type of the genus *Burhinus*. It seems necessary, therefore, to unite the two groups and to use for the combination the older name *Burhinus*, as has already been done by several authors.

Family LARIDAE

Larus cirrhocephalus poiocephalus Swainson

Larus poiocephalus SWAINSON, Nat. Hist. Birds Western Africa, Vol. II, September 23, 1837, p. 245 (no locality; type locality restricted to "West Africa" by Friedmann[2]).

Two specimens, from Lake Rudolf:

Adult male, April 13, 1930. Length, 432 mm. "Iris naphthaline yellow; eyelids brazil red; bill ox-blood red; legs and feet, nopal red washed with scarlet."

Adult male, April 11, 1930. Length, 438 mm.

[The specimen obtained on April 11 was shot from a rock blind on the shore of Lake Rudolf. Another or the same individual was noted there on April 10.—A.B.F.]

[1]Friedmann, Bull. U. S. Nat. Mus., No. 153, Part 1, June 10, 1930, pp. 184-185.
[2]Bull. U. S. Nat. Mus., No. 153, Part 1, June 10, 1930, p. 194.

Family EREMIALECTORIDAE

Pterocles exustus somalicus Hartert

Pterocles exustus somalicus HARTERT, Novit. Zool., Vol. VII, No. 1, March 15, 1900, p. 28 ("Milmil" [Somaliland]).

Eleven specimens:

Adult male, Koroli, March 27, 1930. Length, 292 mm. "Bare space around eye seafoam green."

Adult male, Koroli, March 23, 1930. Length, 305 mm. "Legs and feet, pallid neutral gray."

Adult male, Koroli, March 27, 1930. "Iris black; bare skin around eye seafoam green; bill pale smoke gray; feet drab."

Adult male, Koroli, April 17, 1930. Length, 302 mm.

Four females from Koroli, March 27, 1930. Lengths, 267, 267, 279, and 292 mm., respectively. In one there was an egg ready for extrusion.

Adult female, Koroli, April 17, 1930. Length, 267 mm.

Adult male, Archer's Post, February 28, 1930.

Adult female, Lasamis, March 13, 1930. Length, 291 mm. "Feet pale slate color."

The female taken on April 17 shows slight evidences of molt among the contour feathers.

[Four sand grouse were shot on March 30 at Balessa, and 2 at Lasamis on March 22. At Koroli on April 18 we found a place to which sand grouse were coming to water and we were able to secure several.—W.T.W.]

[At Koroli, March 27, this species was very numerous, occurring singly, in pairs, and in flocks up to at least 100 birds. It stands so low on the ground that it appears to have scarcely any legs. In flight it is swift, dove-like, and noisy. Its note is a guttural chuckle or cluck. We found this bird at sundown along low gravelly ridges featured by short tufts of grass and a few scattered thorn shrubs. It was beginning to nest on March 27 since I killed from a flock 1 which contained an egg nearly ready for laying. At Koroli on March 28 I found a nest about 50 yards from camp. This nest was under a small bush about 15 inches high and consisted of a slight depression in the sand and was without lining. Another nest with eggs was collected on April 16, which nest was in a similar situation and of the same character as the first. On April 18 at the same locality I saw a pair of birds with 2 small young.

At Archer's Post where the country is thorny scrub with very little grass, flocks of sand grouse were watering at a small stream with tussocks of dry grass about knee high on the banks.

At Balessa this sand grouse was wary, and not easily collected. It seemed to be absent from Lake Rudolf.—A.B.F.]

The type genus of the family of sand grouse is the group to which the generic name *Pterocles* Temminck was first restricted by

Bonaparte, and from which the family name Pteroclididae was formed. When W. Sclater transferred the generic name *Pterocles* Temminck to the group formerly known as *Pteroclurus* Bonaparte because of the rectification of the type species of Pterocles, he renamed as *Eremialector* the generic group formerly called *Pterocles*[1]. Since this group is the type genus of the family, its name should be of course the basis of the family name, and hence Eremialectoridae.

For the change of specific name from *senegalensis* to *exustus*, *cf.* Jackson and Sclater, Birds of Kenya Colony and the Uganda Protectorate, Vol. I, 1938, p. 439.

Eremialector decoratus decoratus (Cabanis)

Pterocles decoratus CABANIS, Journ. f. Ornith., Vol. XVI, No. 6, November, 1868, p. 413 ("Ost-Afrika" [=Lake Jipe, near Mount Kilimanjaro]).

Two specimens, from Kinya, taken, May 3, 1930:

Adult male. Length, 243 mm. "Iris dark brown; bare skin around eye barium yellow; bill buckthorn brown; feet wax yellow touched with olive."

Adult female. Length, 235 mm. "Iris dark brown; bare skin around eye barium yellow; bill orange buff; feet wax yellow touched with olive."

The range of this subspecies has been given as south of the Northern Uaso Nyiro, but these specimens come from a point north of that river. They are, however, to be referred here rather than to *Eremialector decoratus ellenbecki.*

Family COLUMBIDAE

Dialiptila guinea guinea (Linnaeus)

[*Columba*]*guinea* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 163 ("Africa" [type locality, Guinea, from Edwards]).

Three specimens:

Adult male, Archer's Post, March 5, 1930. Length, 337 mm. "Iris with outer ring reddish brown, the inner ring yellow; eyelids and bare lores, deep carmine; legs and feet, flesh color."

Adult male, Lasamis, March 14, 1930. Length, 355 mm. "Iris with outer ring eugenia red, inner ring deep chrome; bare space around eye vandyke red; legs and feet, flesh pink."

Adult male, Merile, April 25, 1930. Length, 342 mm. "Iris orange buff, its outer edge reddish; bare skin about eyes between garnet brown and nopal red; bill dark neutral gray, fleshy at base; legs and feet, livid pink."

[The specimen collected on April 25 was shot from a flock of 15.—A.B.F.]

The bifurcate feathers of the neck and the very broad bare space about the eyes structurally set off this species and *Columba*

[1]Bull. Brit. Ornith. Club, Vol. XLII, February 25, 1922, p. 74.

phaeonota Gray from their allies. The subgeneric name *Dialiptila* was proposed for them by Salvadori[1], of which the type by subsequent designation[2] is *Columba guinea* Linneaus. This, therefore, is available as the generic name for the present species.

Streptopelia semitorquata semitorquata (Rüppell)

Columba semitorquata RÜPPELL, Neue Wirbelth. Fauna Abyss., Vögel, 1837, p. 66, pl. XXIII, fig. 2 ("Tarantagebirg" [Ethiopia]).

One adult female, from Gunga Lake, collected on May 28, 1930. Length, 334 mm. "Iris a narrow ring of bittersweet orange; bill slate color; legs and feet, pompeian red."

[On February 25 we noticed this dove watering near a small stream in thorn scrub country having very little grass, south of our camp at Archer's Post.—A.B.F.]

Streptopelia capicola somalica (Erlanger)

Turtur damarensis somalicus ERLANGER, Journ. f. Ornith., Vol. LIII, No. 1, January, 1905, p. 127 ("Sarigo, Süd-Somaliland").

Three specimens:

Adult male, Lasamis, April 24, 1930.

Adult male, Archer's Post, February 26, 1930. Length, 283 mm.

Adult female, Archer's Post, March 5, 1930. Length, 260 mm.

The 2 birds from Archer's Post are darker than the single example from Lasamis, and verge toward *Streptopelia capicola anceps*, although still referable to the present race.

Oena capensis capensis (Linnaeus)

[*Columba*] *capensis* LINNAEUS, Syst. Nat., Ed. 12, Vol. I, 1766, after May 24, p. 286 ("Cap.b.spei" [=Cape of Good Hope]).

Four specimens, all from Koroli:

Adult male, March 24, 1930. Length, 240 mm. "Iris brown; eyelids slate color; tip of bill zinc orange; base of bill, also legs and feet, perilla purple."

Adult male, April 17, 1930. Length, 240 mm. "Iris brown, bare skin around eye light quaker drab; terminal half of bill ochraceous orange, darker at tip; base of bill, together with legs and feet, mineral red."

Adult male, April 17, 1930. Length, 250 mm. "Iris brown; terminal half of bill ochraceous orange, darker at tip; basal half of bill, also legs and feet, mineral red."

Immature male, April 17, 1930. Length, 249 mm. "Iris dark brown; bare skin around eyes hair brown; bill black at tip, bone brown at base; legs and feet, livid brown, dark."

The last mentioned example, though marked "female", is undoubtedly an immature male. It has some black feathers on the sides of the head and of the jugulum, also buffy or buffy white tips on the secondaries, tertials, and some of the upper wing coverts. It is in process of molt.

[1]Cat. Birds Brit. Mus., Vol. XXI, 1893 (after June 30), p. 243 (in text of key).
[2]Richmond, Proc. U. S. Nat. Mus., Vol. XXIV, No. 1267, May 2, 1902, p. 678.

Family CUCULIDAE

Cuculus canorus gularis Stephens

Cuculus gularis STEPHENS, in Shaw's Gen. Zool., Vol. IX, Part 1, 1815, p. 83, pl. XVII (no locality [Camdeboo, Cape Province, ex Levaillant]).

One unsexed adult from Kisima Kufuta, May 7, 1930. Length, 335 mm. "Iris light orange yellow clouded with sudan brown; eyelids light cadmium; base of bill light orange yellow; gape flame scarlet; feet light orange yellow."

This bird is in process of molting the contour feathers.

Clamator jacobinus jacobinus (Boddaert)

Cuculus Jacobinus BODDAERT, Tabl. Planch. Enlum., 1783, after December 1, p. 53 (based on D'Aubenton, Planch. Enlum. d'Hist. Nat., No. 872 [=Coromandel coast of India, ex D'Aubenton]).

Two specimens:

Adult male, Koroli, March 24, 1930. Length, 298 mm. "Iris dark brown; legs and feet, dark neutral gray."

Immature male, Kinya, April 30, 1930. Length, 311 mm. "Iris dark brown; bill black; legs and feet, chaetura drab."

The immature example is, on the upper parts, in process of molting from the brown plumage of the young into the glossy black of the adult, but wing quills and rectrices are not yet involved.

Centropus superciliosus superciliosus Hemprich and Ehrenberg

Centropus superciliosus HEMPRICH and EHRENBERG, Symb. Phys., Aves, 1828 [=1833], fol. R, footnote, pl. XI ("Arabiae et Aethiopiae" [type locality, southern Arabia]).

One adult female, from Archer's Post, February 25, 1930. Length, 379 mm. "Iris carmine; legs and feet, deep gull gray."

This specimen is in process of molt of contour feathers, wing quills, and rectrices.

[Our only specimen was obtained south of camp at Archer's Post on February 25 in the brush near a small stream in thorn scrub country having very little grass.—A.B.F.]

Lampromorpha caprius (Boddaert)

Cuculus caprius BODDAERT, Tabl. Planch. Enlum., 1783, after December 1, p. 40 (based on D'Aubenton, Planch. Enlum. d'Hist. Nat., No. 657 [Cape of Good Hope, ex D'Aubenton]).

Seven specimens:

Adult male, Kisima Kufuta, May 9, 1930. Length, 200 mm.

Adult male, Kinya, May 3, 1930. Length, 191 mm. "Iris nopal red; eyelids scarlet; bill and feet, black."

Adult male, Kinya, May 3, 1930. Length, 185 mm. "Iris nopal red; bill and feet, black."

Adult male, Kinya, April 30, 1930. Length, 191 mm. "Iris with outer ring straw yellow, the inner carmine; eyelids scarlet."

Adult male, Merile, April 28, 1930. Length, 191 mm. "Iris carmine; eyelids scarlet; bill, legs, and feet, chaetura black."

Adult male, Lasamis, April 22, 1930.

Juvenal male, Archer's Post, May 15, 1930. Length, 150 mm.

The juvenal bird differs from the adult in having the anterior upper parts mostly bronzy cinnamon rufous, hazel, or tawny; the metallic green of the rest of the upper surface dull yellowish olive, the feathers edged and tipped with rufous or tawny; the bars on the inner webs of the wing quills likewise cinnamon rufous or tawny instead of white; the edgings, bars, and spots on the tail feathers also mostly tawny or rufous; the anterior lower parts thickly, the posterior surface less numerously, spotted with dull metallic yellowish olive; and the lower tail coverts barred with the same.

Family MUSOPHAGIDAE

Turacus hartlaubi (Fischer and Reichenow)

Corythaix Hartlaubi FISCHER and REICHENOW, Journ. f. Ornith., Vol. XXXII, No. 1, January, 1884, p. 52 ("Fusse des Maeru-Berg (Massai)" [Mount Meru, near Mount Kilimanjaro]).

Ten specimens:

Adult male, Meru, May 26, 1930. Length, 413 mm. "Iris hazel; eyelids scarlet; bill morocco red; legs and feet, dark quaker drab."

Adult female, Meru, May 26, 1930. Length, 399 mm. "Iris hazel; eyelids scarlet; bill morocco red; legs and feet, dark quaker drab."

Male in first nuptial plumage, Gunga Lake, May 22, 1930. Length, 441 mm. "Iris hazel; eyelids scarlet; bill fuscous."

Adult male, Gunga Lake, May 23, 1930.

Adult male, Gunga Lake, May 28, 1930. Length, 440 mm.

Adult female, Gunga Lake, May 26, 1930. Length, 430 mm. "Iris hazel; eyelids scarlet; bill morocco red; legs and feet, dark quaker drab."

Three adult females, Gunga Lake, May 28, 1930. Lengths, 418, 420, and 443 mm.

Adult female, Gunga Lake, May 22, 1930. Length, 425 mm.

The specimens listed above should belong to the race described by E. A. Mearns as *Turacus hartlaubi medius*[1] if this is recognizable; but there seems to be no constant difference between this series and birds from Mount Kilimanjaro.

[Turacos were fairly common in the forests of the region around Gunga Lake. Several were seen in the tall forest on May 23.—A.B.F.]

[1]Smiths. Misc. Coll., Vol. LXV, No. 13, November 26, 1915, p. 3 ("Mount Kenia").

Criniferoides leucogaster (Rüppell)

Chizärhis leucogaster RÜPPELL, Mus. Senck., Vol. III, No. 2, 1842, p. 27 (southern provinces of Abyssinia).

Seven specimens:

Adult male, Lasamis, March 13, 1930. Length, 487 mm. "Iris dark brown; bill, legs, and feet, black."

Adult male, Kinya, May 3, 1930. Length, 488 mm. "Iris hazel; bill, legs, and feet, black."

Adult male, Kinya, May 3, 1930. Length, 485 mm. "Iris hazel; bill, legs, and feet, black."

Adult male, Balessa, March 31, 1930. Length, 508 mm. "Iris brownish olive; bill, legs, and feet, black."

Adult female, Balessa, March 30, 1930. Length, 527 mm.

Adult female, Balessa, March 31, 1930. Length, 508 mm. "Iris bister; bill lumiere green with touch of primuline yellow at base of upper mandible; legs and feet, black."

Adult female, Balessa, March 30, 1930. Length, 483 mm.

The genus *Criniferoides* was proposed by Austin Roberts[1] for the present species, and as it seems well differentiated from *Corythaixoides* A. Smith of which the type is *Corythaix concolor* A. Smith, it should be employed.

Family PSITTACIDAE

Poicephalus rufiventris rufiventris (Rüppell)

Pionus rufiventris RÜPPELL, Syst. Uebers. Vög. Nord-Ost-Afr., 1845, after July, p. 83, pl. XXXII ("Shoa" [Abyssinia]).

Six specimens:

Adult male, Kisima Kufuta, May 10, 1930. Length, 234 mm.

Adult male, Kisima Kufuta, May 6, 1930. Length, 253 mm. "Iris flame scarlet; bare skin around eyes, bill, and feet, black."

Adult female, Kisima Kufuta, May 8, 1930. Length, 235 mm. "Iris with outer ring flame scarlet, the inner buckthorn brown; bare skin around eyes blackish slate; bill dark neutral gray; legs and feet, deep neutral gray."

Adult male, Merile, April 25, 1930. Length, 233 mm. "Iris with outer ring scarlet, the inner ring tawny olive; bill with terminal two-thirds black, the base neutral gray; legs and feet, dark mouse gray."

Adult female, Merile, April 25, 1930. Length, 231 mm. "Iris scarlet with the inner ring tawny olive; skin around eyes black; bill deep neutral gray to black at tip; legs and feet, dark neutral gray."

Adult female, Merile, April 25, 1930. Length, 245 mm. "Iris with outer ring scarlet, the inner ring tawny olive; bare skin around eyes black; bill deep mouse gray at base to blackish mouse gray at tip; legs and feet, mouse gray."

[In the Meru forest on May 24 a flock of about 30 parrots came screeching up along the edge of the forest about half an hour before dusk. They appeared to be larger than those obtained at Merile. —A.B.F.]

[1]Ann. Transvaal Mus., Vol. XI, Part 4, 1926, p. 218.

Family CORACIIDAE

Coracias naevia naevia Daudin

Coracias nœvia[1] DAUDIN, Traité d'Ornith., Vol. II, 1800, p. 258 ("Sénégal").

Two specimens:

Adult male, Archer's Post, May 15, 1930. Length, 350 mm. "Iris brown; bill black; legs and feet, old gold."

Immature male, Kisima Kufuta, May 8, 1930. Length, 356 mm.

The latter individual is in process of molt from the first winter plumage into the first nuptial plumage. Apparently this is only a partial molt, since the primaries, secondaries, and rectrices do not seem to be undergoing change.

The generic name *Coracias* is of feminine gender, and was so considered by its proposer Linnaeus[2] also by most of the earlier authors. Recently, however, many writers, apparently through inadvertence, have treated it as masculine.

Coraciura caudata lorti (Shelley)

Coracias lorti SHELLEY, The Ibis, Ser. 5, Vol. III, No. 12, October, 1885, p. 399 ('Somaliland" [plateau south of Berbera]).

Three specimens:

Adult male, Archer's Post, February 27, 1930. Length, 302 mm. "Iris brown."

Adult male, Archer's Post, February 28, 1930. Length, 297 mm.

Adult female, Kisima Kufuta, May 10, 1930. Length, 323 mm.

These examples from Archer's Post verge toward *Coraciura caudata caudata* but are nearer *Coraciura caudata lorti.*

The rollers allied to the present species have a remarkable elongation of the outermost tail feather on each side. The generic name for these is *Coraciura* Bonaparte[3]. To the genus there should be referred the following:

Coraciura abyssinica (Hermann)
Coraciura spatulata spatulata (Trimen)
Coraciura spatulata dispar (Bocage)
Coraciura caudata caudata (Linnaeus)
Coraciura caudata lorti (Shelley)
Coraciura cyanogastra (Cuvier)

Eurystomus afer suahelicus Neumann

[*Eurystomus afer*] *suahelicus* NEUMANN, Journ. f. Ornith., Vol. LIII, No. 1, January, 1905, p. 186 ("Tschara, am Tana" [River, Kenya Colony]).

A single adult female, collected at Kinya on May 4, 1930. Length, 290 mm. "Iris brown."

[1]Typographical error; corrected to *naevia* on page 463.

[2]Syst. Nat., Ed. 10, Vol. I, January 1, 1758, pp. 83, 107.

[3]Conspectus Volucrum Anisodactylorum, Ateneo Italiano, Vol. II, No. 11, August 15, 1854, p. 317 (type, *Coracias cyanogastra* Cuvier).

Family ALCEDINIDAE

Halcyon leucocephala leucocephala (Müller)

Alcedo leucocephala P.L.S.MÜLLER, Vollst. Natursyst. Suppl., 1776, p. 94 ("Senegal").

A single immature male, from Archer's Post, taken, February 28, 1930. Length, 216 mm. "Iris brown; bill scarlet."

[The only specimen was collected on February 28 near the small marsh not far from our camp at Archer's Post.—A.B.F.]

Halcyon chelicuti chelicuti (Stanley)

Alcedo Chelicuti STANLEY, in Salt, Voyage Abyssinia, Appendix IV, 1814, p. lvi ("Chelicut, Abyssinia").

Four specimens:

Adult male, Archer's Post, February 28, 1930. Length, 178 mm. "Iris drab brown."

Adult unsexed, Archer's Post, May ...., 1930.

Adult male, Kisima Kufuta, May 12, 1930. Length, 180 mm.

Adult female, Kisima Kufuta, May 7, 1930. Length, 178 mm. "Iris dark brown; lower mandible carnelian red."

[The specimen from Archer's Post obtained on February 28 came from near a small marsh a short distance from our camp. —A.B.F.]

Family MEROPIDAE

Melittophagus pusillus cyanostictus (Cabanis)

Merops cyanostictus CABANIS, in von der Decken's Reisen Ost-Afrika, Vol. III, Part 1, 1869, p. 34 ("Mombas. Dschagga" [German East Africa; restricted type locality, Mombasa]).

Two adult males, from Kenya, but without further data. Both are in process of molt.

Melittophagus lafresnayii oreobates Sharpe

Melittophagus oreobates SHARPE, The Ibis, Ser. 6, Vol. IV, No. 14, April, 1892, p. 320 ("Savé, Elgon, 6000 feet" [Mount Elgon, Kenya Colony]).

One adult male, Gunga Lake, May 28, 1930. Length, 227 mm. "Iris nopal red; feet dark olive gray."

This specimen is in process of molting the wing and tail feathers.

Melittophagus revoilii (Oustalet)

Merops Revoilii OUSTALET, Miss. Révoil Pays Çomalis, Oiseaux, 1882, p. 5, pl. I ("Pays des Çomalis").

One adult female, from Balessa, March 30, 1930. Length, 178 mm.

This bird is in much worn plumage but shows no indication of molt.

Family BUCEROTIDAE

Bycanistes cristatus brevis Friedmann

Bycanistes cristatus brevis FRIEDMANN, Proc. New England Zoöl. Club, Vol. XI, August 6, 1929, p. 32 ("Mt. Lutindi, Usambara Mountains, Tanganyika Territory").

Six specimens, from Gunga Lake:

Adult male, May 22, 1930. Length, 850 mm. "Iris dark brown; face black."

Two adult males, May 23, 1930. Lengths, 842 and 862 mm.

Adult female, May 23, 1930. Length, 785 mm. "Face fleshy white; legs and feet, puritan gray, their scutes black."

Adult female, May 23, 1930. Length, 781 mm.

Adult female, May 26, 1930. Length, 822 mm. "Iris hazel; skin around eye flesh color."

These examples agree in measurements with those of the small race named *Bycanistes cristatus brevis* by Friedmann. They further indicate that this is a recognizable subspecies.

[A group of 5 was seen flying over the forest near Nanyuki on February 23. This hornbill was fairly common in the region about Gunga Lake, May 23; and large numbers were seen on the following day along the lower edge of the forest.—A.B.F.]

Lophoceros erythrorhynchus leucopareus (Hemprich and Ehrenberg)

Buceros, Alophius, erythrorrynchus var. *leucopareus* HEMPRICH and EHRENBERG, Symb. Phys., Aves, 1828 [=1833], fol. aa, footnote 1 ([littoral] Abyssinia).

Three specimens:

Adult male, Kisima Kufuta, May 6, 1930. Length, 492 mm.

Adult female, Archer's Post, March 5, 1930. Length, 419 mm. "Iris brown; bare skin around eye pale russian blue; bill morocco red, but darker at tip and flesh color at base."

Adult unsexed, Archer's Post, May, 1930.

[Near Gunga Lake at dusk on May 24 I saw 4 hornbills of this species moving upward along the edge of the big trees.—A.B.F.]

Birds of this species from Kenya have more curved, *less* heavy bills than those examined from Senegal, the type region of *Lophoceros erythrorhynchus erythrorhynchus* (Temminck), and indicate the distinctness of an eastern race, ranging from the Sudan, Abyssinia, and Eritrea, south to Tanganyika Territory. This has already been suggested by Van Someren[1].

Lophoceros flavirostris flavirostris (Rüppell)

Buceros flavirostris RÜPPELL, Neue Wirbelth. Fauna Abyss., Vögel, Part 2, 1835, p. 6, pl. II, fig. 2 ("Fusse des Taranta-Gebirgs unfern Massaua" [Ethiopia]).

Three specimens, all from Lasamis:

[1]Novit. Zool., Vol. XXIX, No. 1, 1922, p. 76.

Adult male, March 13, 1930. Length, 518 mm. "Iris pale yellow; bill yellow ocher tipped with reddish brown."

Adult male, April 22, 1930.

Adult female, April 23, 1930.

Lophoceros melanoleucos suahelicus Neumann

Lophoceros melanoleucos suahelicus NEUMANN, Journ. f. Ornith., Vol. LIII, No. 1, January, 1905, p. 187 ("Morogoro" [German East Africa]).

Four specimens:

Adult male, Gunga Lake, May 23, 1930. Length, 525 mm.

Adult male, Meru, May 26, 1930. Length, 567 mm. "Iris orange buff; bill vinaceous rufous, with maize yellow basal margin."

Adult male, Meru, May 26, 1930. Length, 543 mm. "Bill orange cinnamon, with pale yellowish tint at basal margin; feet black."

Adult female, Meru, May 26, 1930. Length, 525 mm. "Iris pale orange yellow; bill vinaceous rufous with maize yellow basal margin, and nearly claret brown tip; skin at base of lower mandible pale yellow green."

These specimens indicate the distinctness of *Lophoceros melanoleucos suahelicus*.

Family UPUPIDAE

Upupa epops somalensis Salvin

Upupa somalensis SALVIN, Cat. Birds Brit. Mus., Vol. XVI, October, 1892, p. 13, pl. I ("Somali").

A single adult male collected at Kinya on May 3, 1930, is in the collection. Length, 289 mm. "Iris brown."

The original spelling of the subspecific name is as above given, although it is commonly printed *somaliensis*.

Upupa africana Bechstein

U[pupa]. africana BECHSTEIN, Latham's Allgem. Uebers. Vögel, Vol. IV, 1811, p. 172 ("Congo und Vorgebirge der guten Hoffnung" [type locality, Cape of Good Hope, South Africa[1]]).

Two specimens:

Adult female, Kisima Kufuta, May 8, 1930. Length, 266 mm. "Iris hazel."

Immature female, Kinya, May 1, 1930. Length, 278 mm. "Iris brown."

Family PHOENICULIDAE

Phoeniculus purpureus marwitzi (Reichenow)

Irrisor erythrorhynchus marwitzi REICHENOW, Ornith. Monatsb., Vol. XVI, No. 11, November, 1906, p. 171 ("Mkalama am Ostrande

[1]Designated by Oberholser, Proc. U. S. Nat. Mus., Vol. XXVIII, No. 1411, July 8, 1905, p. 856.

der Wemberestreppe" [Kondoa Irangi district, Tanganyika Territory]).

Two specimens, from Archer's Post, collected, February 26, 1930:

Adult male. Length, 394 mm. "Iris brown; bill scarlet, the top edged with black; legs and feet, scarlet."

Adult male. Length, 454 mm. "Iris brown; bill scarlet, edged with black; legs scarlet."

Phoeniculus purpureus niloticus (Neumann)

Irrisor erythrorynchos niloticus NEUMANN, Ornith. Monatsb., Vol. XI, No. 12, December, 1903, p. 181 ("Goz abu Guma, am weissen Nil").

A single adult female, taken at Kisima Kufuta, May 7, 1930, is in the collection. Length, 395 mm. "Iris dark brown; bill nopal red; legs and feet, between nopal red and scarlet."

This individual is somewhat intermediate between *Phoeniculus purpureus niloticus* and *Phoeniculus purpureus marwitzi*, but is nearer the former. It is thus a southern extension of range for this subspecies from the Endoto Mountains which apparently are its southernmost previous locality. Birds from Archer's Post, however, only a short distance farther south are *Phoeniculus purpureus marwitzi*.

Phoeniculus granti (Neumann)

Irrisor damarensis granti NEUMANN, Ornith. Monatsb., Vol. XI, No. 12, December, 1903, p. 182 ("Ngomeni in Ukamba" [Kenya Colony]).

Three specimens, all from Archer's Post:

Adult male, February 26, 1930. Length, 413 mm. "Iris brown; bill scarlet, edged with black; legs and feet, scarlet."

Adult male, February 2, 1930. Length, 426 mm.

Immature unsexed, February 26, 1930.

Phoeniculus bollei jacksoni (Sharpe)

Irrisor Jacksoni SHARPE, Ann. and Mag. Nat. Hist., Ser. 6, Vol. VI, No. 36, December, 1890, p. 503 ("Kikuyu Country" [Kenya Colony]).

Six specimens:

Two adult males, Meru, May 26, 1930. Lengths, 360 and 360 mm. "Iris dark brown; bill ox-blood red; eyelids, legs, and feet, nopal red."

Immature male, Meru, May 26, 1930. Length, 346 mm. "Iris dark brown; bill black; eyelids maroon; legs and feet, brazil red, washed with brown."

Adult female, 20 miles west of Meru (in forest), May 23, 1930. Length, 336 mm.

Two adult females, 20 miles west of Meru, May 23, 1930. Lengths, 312 and 337 mm.

Family BUBONIDAE

Bubo africanus cinerascens Guérin-Méneville

Bubo cinerascens GUÉRIN-MÉNEVILLE, Rev. Zool., Vol. VI, No. 11, November, 1843, p. 321 ("Abyssinie" [=Ethiopia]).

One adult female, from Kinya, May 2, 1930. Length, 377 mm. "Iris brown."

Bubo lacteus (Temminck)

Strix lactea TEMMINCK, Nouv. Rec. Planches Col. Ois., Vol. II, Livr. 1, April, 1822, pl. IV ("Sénégal, sur ce fleuve").

One adult female, from Gunga Lake, May 19, 1930. Length, 570 mm. "Iris dark."

Family CAPRIMULGIDAE

Caprimulgus poliocephalus poliocephalus Rüppell

Caprimulgus poliocephalus RÜPPELL, Neue Wirbelth. Fauna Abyss., Vögel, 1840, p. 106 ("Kulla" [Abyssinia]).

One adult female, Gunga Lake, May 28, 1930. Length, 238 mm.

Caprimulgus fossei apatelius Neumann

Caprimulgus apatelius NEUMANN, Ornith. Monatsb., Vol. XII, No. 9, September, 1904, p. 143 ("Galana-Fluss, am Abaya-See" [southern Ethiopia]).

Two specimens:

Adult female, Lasamis, March 13, 1930. Length, 217 mm. "Iris dark brown; legs and feet, japan rose."

Adult male, from Kenya, without further data.

[On April 16 at Koroli we flushed a bird of this species from its nest on flat bare ground near a lava escarpment. There was no real nest but the 2 eggs rested on bare flat earth near a small lava cinder about the size of one's fist. At our approach the bird flew off into the rough lava rocks.—A.B.F.]

Family MICROPODIDAE

Cypsiurus parvus myochrous (Reichenow)

Cypselus myochrous REICHENOW, Journ. f. Ornith., Vol. XXXV, No. 1, January, 1886, p. 116 ("Karema" [Tanganyika Territory]).

One adult male, from Archer's Post, collected, February 28, 1930. Length, 116 mm. "Iris gray."

[This swift was abundant on February 25 near the Northern Uaso Nyiro at Archer's Post. It was frequently seen there skimming in and out amongst the tall palms.—A. B. F.]

Family COLIIDAE

Colius striatus kikuyuensis Van Someren

Colius striatus kikuyuensis VAN SOMEREN, Bull. Brit. Ornith. Club, Vol. XL, No. CCXLV, December 8, 1919, p. 27 ("Nairobi").

Two specimens, collected at Gunga Lake, May 21, 1930.

Adult male. Length, 287 mm. "Iris dark brown; bare skin of

face, neutral gray; bill black, streaked with primrose yellow on top; legs and feet, old rose."

Adult female. Length, 295 mm. "Iris dark brown; bare skin around eyes dark slate color; bill black, streaked with primrose yellow on top; legs and feet, old rose."

Colius leucocephalus turneri Van Someren

Colius leucocephalus turneri VAN SOMEREN, Bull. Brit. Ornith. Club, Vol. XL, No. CCXLV, December 8, 1919, p. 27 ("Northern Guasso N'yiro").

One adult female, from Balessa, March 31, 1930. Length, 330 mm. "Iris brown; bare skin around eye chaetura black; bill pale prussian blue, tipped with black; legs and feet, old rose."

Urocolius macrourus pulcher (Neumann)

Colius macrourus pulcher NEUMANN, Journ. f. Ornith., Vol. XLVIII, No. 2, April, 1900, p. 190 ("Bura, Teita").

Five specimens:

Adult female, Balessa, March 31, 1930. Length, 311 mm. "Iris garnet brown; bare skin around eyes carmine; bill rose doree to carmine at base, and black at tip; legs and feet, livid brown."

Immature female, Kinya, April 30, 1930. Length, 247 mm. "Iris hazel; bare space around eyes deep mouse gray; bill pearl gray; the space around nostrils chartreuse yellow, at gape citron green; legs and feet, deep purplish vinaceous."

Adult male, Kinya, April 30, 1930. Length, 336 mm. "Iris garnet brown; bare space around eyes ox-blood red; basal half of bill carmine, the tip black, with a light blue line between these 2 colors; legs and feet, deep purplish vinaceous."

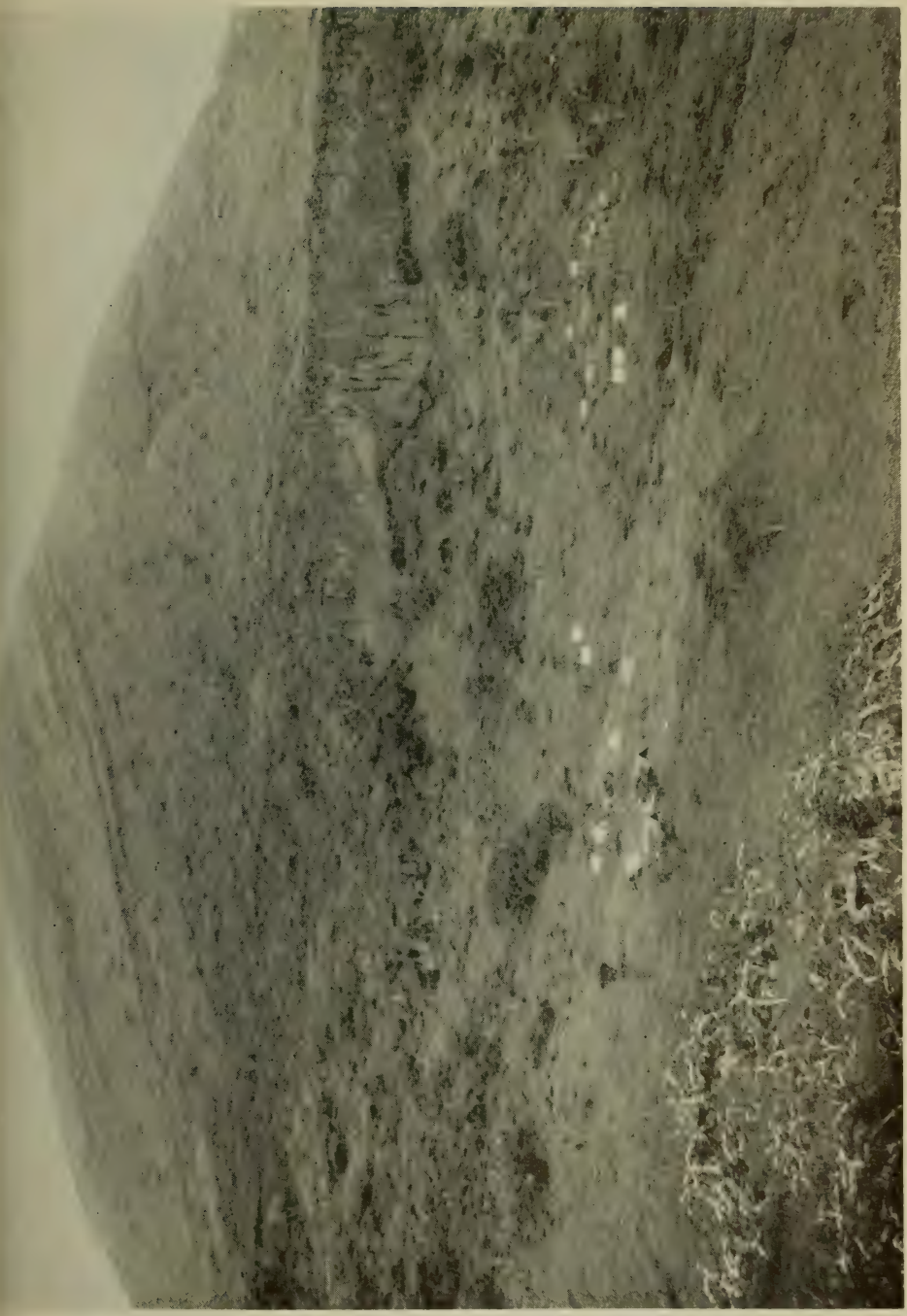
Adult female, Kisima Kufuta, May 9, 1930. Length, 284 mm.

Adult unsexed, Kisima Kufuta, May 9, 1930. Length, 292 mm.

All these examples except the first are more or less in process of molt.

Further examination of pertinent material seems to indicate that the birds of this species from Abyssinia (Ethiopia) are subspecifically separable from those of Senegal, although Friedmann[1] considers them identical. Both are, of course, different from *Urocolius macrourus pulcher*. Senegal specimens average in wing measurement 88 mm., thus smaller than birds from Abyssinia, a good series of which averages 90.8 mm. Furthermore, in the western (Senegal) race the maxilla has a more extensive black tip, the carmine at the base (yellow in the dried skin) being consequently less extensive than in the Abyssinian bird. This difference though slight is easily appreciable. Only 1 of the specimens from Abyssinia has as long an area of black on the maxilla as have the individuals of the Senegal

[1]Bull. U. S. Nat. Mus. No. 153, Part 1, June 10, 1930, pp. 331-333.



Camp of the White-Fuller Expedition at the Southern End of Mount Kulal, Looking Northeast. April 6, 1930.

MEMBERS OF THE EXPEDITION ARRIVE ON THE SOUTHEASTERN SHORE OF LAKE RUDOLF. LOOKING SOUTHWEST FROM THE LAKE SHORE NEAR CAMP. THE ROUGH, LAVA-STREWN GROUND MAKES WALKING UNPLEASANT. April 10, 1930.

PROTECTIVELY COLORED YOUNG SOMALI OSTRICHES (*Struthio camelus molybdophanes*) AT BALESSA. March 30, 1930.

HOODED VULTURES *(Necrosyrtes monachus pileatus)* AND A MARABOU *(Leptoptilos crumeniferus)* VIEWING THE EXPEDITION'S CAMP FROM AN ACACIA TREE AT ARCHER'S POST, March 1, 1930

race. Birds from Senegal differ also in being more buffy below than Abyssinia examples.

The name to be applied to the race from Abyssinia above diagnosed is *Urocolius macrourus syntactus* Oberholser[1], since *Lanius macrourus* Linnaeus[2] was based on the bird from Senegal.

As has already been pointed out by the writer[3], *Lanius macrourus* Linnaeus and *Colius indicus Latham* should be generically separated from the rest of the colies, under the generic term *Urocolius* Bonaparte[4].

This group differs from the genus *Colius* in having the tail-feathers very narrow and stiff; the first (outermost) primary longer than the eighth, instead of much shorter; the nostrils linear or narrowly elliptical instead of rounded or oval; and the gonys not ascending but horizontal, in a line with the lower margin of the rami.

Family TROGONIDAE

Heterotrogon vittatus keniensis Bowen

Heterotrogon vittatum keniensis BOWEN, Proc. Acad. Nat. Sci. Phila., Vol. LXXXII, October 1, 1930, p. 265 ("forest above Meru, Kenya Colony").

Two specimens, from Meru, May 29, 1930:

Adult male. Length, 292 mm. "Iris ox-blood red; a patch below each eye orange; bill glass green; legs and feet, light vinaceous."

Adult female. Length, 283 mm. "Iris ox-blood red; patch below and behind each eye orange; lower mandible and basal half of upper mandible, glass green; legs and feet, light vinaceous fawn."

The male is in process of molt.

[One individual was discovered on May 25 among some dense trees on the steep sides of the crater walls above Gunga Lake. —A. B. F.]

The gender of the generic name *Heterotrogon* should be masculine, like *Trogon;* and its original describer without doubt unintentionally treated it as neuter, as have most subsequent authors.

Family CAPITONIDAE

Buccanodon leucotis kenyae (Bowen)

Smilorhis leucotis kenyæ BOWEN, Proc. Acad. Nat. Sci. Phila., Vol. LXXXII, March 22, 1930, p. 3 ("Meru, Kenya Colony").

A single adult male, taken at Meru, May 29, 1930. "Iris dark brown; bill and feet, black."

Trachyphonus böhmi böhmi Fischer and Reichenow

Trachyphonus Böhmi FISCHER and REICHENOW, Journ. f. Ornith., Vol. XXXII, No. 1, January, 1884, p. 179 ("Pare-Gebirge, Aruscha,

[1]Proc. U. S. Nat. Mus., Vol. XXVIII, No. 1411, July 8, 1905, p. 863 (in text) ("Abyssinia").

[2]Syst. Nat., Ed. 12, Vol. I, 1766, after May 24, p. 134.

[3]Oberholser, Proc. U. S. Nat. Mus., Vol. XXVIII, No. 1411, July 8, 1905, p. 863.

[4]Conspectus Volucrum Anisodactylorum, Ateneo Italiano, Vol. II, No. 11, August 15, 1854, p. 313 (type, *Lanius macrourus* Linnaeus).

Ukamba,Barawa" [type locality, Barawa, Juba River, Italian Somaliland]).

Three specimens:

Adult male, Kinya, May 1, 1930. Length, 199 mm. "Iris morocco red."

Adult female, Koroli, March 25, 1930. Length, 203 mm.

Adult male, Koroli, March 25, 1930. Length, 194 mm.

Although sometimes considered a subspecies of *Trachyphonus darnaudii*, the wholly black pileum and black throat patch, together with apparent lack of actual intergradation, indicate that it is a distinct species.

Family PICIDAE

Campethera taeniolaema hausburgi Sharpe

Campothera hausburgi SHARPE, Bull. Brit. Ornith. Club, Vol. X, No. LXVIII, January 31, 1900, p. 36 ("Mt. Kenya").

One adult female, from Meru, collected, May 26, 1930. "Iris carmine; bill dusky neutral gray; legs and feet, light hellebore green."

Campethera nubica nubica (Boddaert)

Picus Nubicus BODDAERT, Tabl. Planch. Enlum., 1783, after December 1, p. 41 (based on D'Aubenton, Planch. Enlum. d'Hist. Nat., No. 667; type locality, Nubia).

Two specimens:

Adult female, Archer's Post, February 27, 1930. Length, 297 mm. "Iris acajou red."

Immature female, Kinya, May 1, 1930. Length, 176 mm. "Iris brown; bill blackish plumbeous; legs and feet, dawn gray."

The latter bird is apparently in a transition plumage between the juvenal and first winter plumage. It differs from the adult female in having smaller white spots on the pileum; a narrower red band on the occiput; upper surface including the wings paler, the light markings in general larger; and the dark spots on the jugulum and breast duller, more brownish, less intensely black.

Dendropicos fuscescens hemprichii (Ehrenberg)

Picus Hemprichii EHRENBERG, in Hemprich and Ehrenberg, Symb. Phys., Aves, 1828 (=1833) fol. r, footnote ("Arkiko" [Ethiopia]).

Two adult males, from Balessa, taken, April 8, 1930. Lengths, 140 and 145 mm., respectively. "Iris carmine; legs and feet, andover green."

Family ALAUDIDAE

Spilocorydon africanus athi (Hartert)

Mirafra africana athi HARTERT, Novit. Zool., Vol. VII, No. 1, March 15, 1900, p. 46 ("Athi Plain, British East Africa" [Kenya Colony]).

One adult male, Archer's Post, February 25, 1930. Length, 203 mm. "Iris brown; legs and feet, tilleul buff."

The elongated operculate nostrils and other characters serve to separate this species generically from *Mirafra*.

Calendulauda poecilosterna poecilosterna (Reichenow)

Alauda pœcilosterna REICHENOW, Ornith. Centralbl., Vol. IV, No. 20, October 15, 1879, p. 155 ("Kibaradja" [Tana River, Kenya Colony]).

Two specimens:

Adult female, Lasamis, March 14, 1930. Length, 167 mm.

Adult female, Koroli, April 17, 1930. Length, 175 mm. "Iris light brown; bill black; legs and feet, avellaneous."

The rather slender bill and circular nostrils situated in the middle of the nasal fossae, together with its other characters, distinguish this species, which is worthy of generic separation from *Mirafra*.

Calendulauda poecilosterna massaica (Fischer and Reichenow)

Megalophonus massaicus FISCHER and REICHENOW, Journ. f. Ornith., Vol. XXXII, No. 1, January, 1884, p. 55 ("Klein-Aruscha" [Tanganyika Territory]).

One unsexed specimen, from Archer's Post, collected, February 25, 1930. Length, 175 mm.

Galerida cristata somaliensis Erlanger

Galerida cristata somaliensis (REICHENOW MS.) ERLANGER, Journ. f. Ornith., Vol. LV, No. 1, January, 1907, p. 49 ("Zeila" [Somaliland]).

Seven specimens:

Adult male, Lake Rudolf, April 13, 1930. Length, 175 mm.

Adult female, Koroli, March 26, 1930. Length, 167 mm. "Upper mandible drab; lower mandible pale drab gray; legs and feet, ecru drab."

Adult male, Koroli, March 26, 1930. Length, 161 mm. "Upper mandible buffy brown; lower mandible tilleul buff; legs and feet, avellaneous."

Juvenal male, Koroli, March 26, 1930. Length, 147 mm. "Bill drab gray, touched with hair brown; legs and feet, light mineral gray."

Juvenal male, Koroli, April 15, 1930. Length, 171 mm. "Iris hazel; upper mandible hair brown; lower mandible pale drab gray; legs and feet, drab gray."

Juvenal female, Koroli, April 15, 1930. Length, 171 mm. "Iris hazel; upper mandible hair brown; lower mandible pale drab gray; legs and feet, pale drab gray."

Juvenal female, Koroli, April 15, 1930. Length, 178 mm. "Upper mandible hair brown; lower mandible pale drab gray; legs and feet, drab gray."

[At Lake Rudolf on April 12 this lark was the most common land bird, and was responsible for most of the bird notes heard there.—A.B.F.]

Eremopteryx signata (Oustalet)

Pyrrhulauda signata OUSTALET, Bibliothéque École Hautes Études, Vol. XXXI, Art. 10, 1886, p. 9 ("Somaliland").

Four specimens, from Koroli:

Adult male, April 16, 1930. Length, 127 mm. "Iris hazel; bill pale gull gray; legs and feet, light cinnamon drab."

Adult male, March 26, 1930. "Iris brown; bill pale olive gray; legs and feet, avellaneous."

Adult female, April 16, 1930. Length, 121 mm. "Iris hazel; bill drab; legs and feet, light pinkish cinnamon."

Immature male, March 26, 1930. Length, 128 mm. "Iris brown; bill pale olive gray; legs and feet, avellaneous."

Family MOTACILLIDAE

Budytes flavus thunbergi (Billberg)

[*Motacilla*] *Thunbergi* BILLBERG, Syn. Faun. Scand., Vol. I, Part 2, Aves, 1828, p. 50 ("Lapponia ad Enontekis et Enara").

A single adult male is in the collection. It was obtained at Archer's Post on February 27, 1930. Length, 159 mm. "Iris brown."

Budytes flavus rayi Bonaparte

Budytes Rayi (GOULD MS.) BONAPARTE, Geogr. and Comp. List Birds Eur. and North Amer., April, 1838, p. 18 ("British Islands" [restricted type locality, England]).

One immature male, from Lake Rudolf, April 13, 1930. Length, 160 mm.

Anthus nicholsoni neumannianus Collin and Hartert

Anthus nicholsoni neumannianus COLLIN and HARTERT, Novit. Zool., Vol. XXXIV, No. 1, August 10, 1927, p. 50 (nom. nov. pro *Anthus nicholsoni longirostris* Neumann, Ornith. Monatsb., Vol. XIII, No. 5, May, 1905, p. 77 (" Gardulla am Gandjule-See" [southern Ethiopia]).

Two specimens:

Adult male, Mount Kulal, altitude 5500 feet, April 5, 1930. Length, 180 mm.

Adult male, Crater Lake, March 17, 1930. Length, 180 mm. "Iris brown."

Both of these individuals are in worn plumage, but not yet in molt.

Tmetothylacus tenellus (Cabanis)

Macronix tenellus CABANIS, Journ. f. Ornith., Vol. XXVI, No. 2, April, 1878, p. 205 ("Ost-Afrika"; "Teita" [on p. 220; Kenya Colony]).

Four specimens:

Adult male, Koroli, April 17, 1930. Length, 165 mm. "Iris hazel; legs and feet, neutral gray."

Adult male, Lasamis, March 14, 1930, Windsor T. White. Length, 159 mm.

Adult male, Merile, April 27, 1930. Length, 159 mm.

Adult male, Merile, April 27, 1930. Length, 159 mm.

The localities at which the above-listed specimens of this remarkable bird were obtained are apparently new stations for the species.

Macronyx croceus croceus (Vieillot)

Alauda crocea VIEILLOT, Nouv. Dict. d'Hist. Nat., Vol. I, 1816, p. 365 ("Java" [type locality subsequently given by Swainson as Senegal]).

A single immature male, from Gunga Lake near Meru, obtained on May 25, 1930. Length, 216 mm.

Family TIMELIIDAE

Turdoides hypoleucus (Cabanis)

Crateropus hypoleucus CABANIS, Journ. f. Ornith., Vol. XXVI, No. 2, April, 1878, p. 205 ("Ost-Afrika"; "Kitui" [on p. 226; Ukamba, Kenya Colony]).

A single adult female, taken at Gunga Lake, May 25, 1930. Length, 245 mm.

In passing it might be worth while to call attention to the fact that the generic name *Turdoides* is of masculine, not feminine, gender, as some recent authors have apparently thought. It is of identical orthography with such generic names as *Picoides*, *Regulaides*, and others, all of which are properly used as masculine. All these words are adjectives with masculine termination like the Latin adjective hyaloides and others, but treated of course as nouns because employed as generic names. Were they feminine they would have the termination 'is' instead of 'es'.

Cossypha heuglini heuglini Hartlaub

Cossypha Heuglini HARTLAUB, Journ. f. Ornith., Vol. XIV, No. 1, January, 1866, p. 36 ("Keren" [error for Wau, Bahr el Ghazal; *cf.* Heuglin, Ornith. Nordost-Afr., Vol. I, 1869, p. 375]).

One adult male, from Crater Lake, March 17, 1930. Length, 240 mm. "Iris brown."

This example is in process of molt.

The present writer has previously called attention[1] to the unsatisfactory reference of the genus *Cossypha* to the Turdidae, because of its scutellated tarsi. It seems much more at home in the Timeliidae.

[1]Proc. U. S. Nat. Mus., Vol. XXVIII, No. 1411, July 8, 1905, p. 894.

Family PYCNONOTIDAE

Pycnonotus dodsoni dodsoni Sharpe

Pycnonotus dodsoni SHARPE, Proc. Zool. Soc. London, Vol. for 1895, No. 3, October 1, 1895, p. 488 ("Sillul" [Ogaden, western Somaliland]).

Four specimens:

Adult male, Crater Lake, March 17, 1930. Length, 172 mm. "Iris dark brown."

Adult male, Balessa, March 31, 1930. Length, 178 mm. "Iris brown; bill, legs, and feet, fuscous black."

Adult male, Lasamis, April 23, 1930.

Immature male, Lasamis, April 22, 1930.

All these individuals are more or less in process of molt.

Pycnonotus dodsoni peasei Mearns

Pycnonotus layardi peasei MEARNS, Smiths. Misc. Coll., Vol. LVI, No. 20, April 17, 1911, p. 8 ("Pease's Farm, Kitunga, British East Africa" [Kenya Colony]).

Two specimens, from Gunga Lake:

Adult male, May 25, 1930. Length, 194 mm.

Adult male, May 20, 1930. Length, 198 mm.

Both of these are in process of molt both of wing quills and contour feathers.

This is evidently a recognizable race, although by some ornithologists not so considered. As stated by Friedmann[1] it is larger and darker than *Pycnonotus dodsoni dodsoni.*

Pycnonotus tricolor fayi Mearns

Pycnonotus layardi fayi MEARNS, Smiths. Misc. Coll., Vol. LVI, No. 20, April 17, 1911, p. 7 ("Fay's Farm, N'jabini, British East Africa" [Kenya Colony]).

A single immature specimen, from Nairobi, but without further data.

It is in process of molt.

Phyllastrephus fischeri placidus (Shelley)

Xenocichla placida SHELLEY, Proc. Zool. Soc. London, Vol. for 1889, No. 3, October 1, 1889, p. 363 ("Kilimanjaro, 6000 feet" [Tanganyika Territory, East Africa]).

Three specimens:

Adult male, Meru, May 29, 1930. Length, 195 mm. "Iris light brown; bill black; legs and feet, pale payne gray."

Adult male, Meru, May 29, 1930. Length, 203 mm. "Iris olive brown; legs and feet, light payne gray."

[1]Bull. U. S. Nat. Mus., No. 153, Part 2, June 23, 1937, p. 106.

Adult female, Gunga Lake, May 28, 1930. Length, 190 mm. "Iris mikado brown; bill black at tip, lighter at base; legs and feet, light payne gray."

Stelgidillas gracilirostris percivali (Neumann)

Criniger gracilirostris percivali NEUMANN, Ornith. Monatsb., Vol. XI, No. 12, December, 1903, p. 185 ("Fort Smith, Kikuyu").

A single adult male of this rare bulbul is in the collection. It was collected at Meru on May 29, 1930. Length, 195 mm. "Iris maroon; bill and feet, black."

Family MUSCICAPIDAE

Muscicapa striata neumanni Poche

Muscicapa grisola neumanni POCHE, Ornith. Monatsb., Vol. XII, No. 2, February, 1904, p. 26 (nom. nov. pro *Muscicapa grisola sibirica* Neumann, nec Gmelin).

One adult male, from Balessa, was obtained on April 8, 1930. Length, 147 mm.

Alseonax gambagae somaliensis (Bannerman)

Muscicapa somaliensis BANNERMAN, Bull. Brit. Ornith. Club, Vol. XXV, No. CLV, November 30, 1909, p. 20 ("Waghar Mountains, N. Somaliland").

One adult, sex uncertain, from Archer's Post, February 28, 1930. Length, 125 mm. "Iris brown."

It forms apparently the first certain record for Kenya Colony.

This bird, placed in the genus *Muscicapa* by some recent authors, really agrees better in structural generic details with the genus *Alseonax*, particularly in so far as the primaries are concerned. An analysis of the characters of these and related genera was some time ago published by the present writer[1].

Bradornis microrhynchus erlangeri Reichenow

[*Bradornis griseus*] var. *erlangeri* REICHENOW, Vögel Afr., Vol. III, Part 2, October, 1905, p. 830 (in text) ([Hanole, southern] "Somalilande").

Five specimens:

Adult male, Archer's Post, February 28, 1930. Length, 141 mm. "Iris brown."

Adult male, Archer's Post, February 28, 1930. Length, 152 mm. "Iris brown."

Adult female, Archer's Post, February 26, 1930. Length, 152 mm. "Iris brown."

Adult male, Balessa, March 31, 1930. Length, 146 mm. "Iris brown; bill black; legs and feet, fuscous black."

[1]Proc. U. S. Nat. Mus., Vol. XXVIII, No. 1411, July 8, 1905, p. 911.

Juvenal female, Balessa, March 31, 1930. Length, 146 mm. "Legs and feet, deep neutral gray."

The juvenal plumage differs from that of the adult in having the upper surface much less uniform, the pileum streaked with much darker grayish brown and with buffy white; remainder of the upper surface spotted and streaked with buffy white, buff, and dark brown; tips of upper wing coverts with terminal spots of buff and buffy white; lower surface with much less buff, particularly on anterior areas, in fact, almost pure white, with streaks of hair brown on breast and jugulum.

Melaenornis pammelaina tropicalis (Cabanis)

Melanopepla tropicalis CABANIS, Journ. f. Ornith., Vol. XXXII, No. 2, April, 1884, p. 241 ("Ost-Afrika" [=Ikanga, Ukamba, Kenya Colony]).

One adult male, Kisima Kufuta, May 13, 1930. Length, 191 mm. "Iris dark brown, bill, legs, and feet, black."

Batis molitor puella Reichenow

Batis puella REICHENOW, Jahrb. Hamburg wiss. Anst., Vol. X, Part 1, 1893, p. 125 (Bussisi, Tanganyika Territory).

One adult male, from Meru, May 26, 1930. Length, 121 mm. "Iris cosse green; bill, legs, and feet, black."

This individual is in process of molt. Its head and back are darker, more blackish than the same parts in birds from more western and southern localities in Kenya.

Terpsiphone viridis ferreti (Guérin-Méneville)

Tchitrea Ferreti GUÉRIN-MÉNEVILLE, Rev. Zool., Vol. VI, No. 6, June, 1843, p. 162 ("Abyssinie").

Five specimens:

Male, subadult (long-tailed chestnut stage), Meru, May 26, 1930. Length, 345 mm. "Iris dark brown; eyelids windsor blue; bill columbia blue, legs and feet, payne gray."

Male, subadult (long-tailed chestnut stage), Meru, May 29, 1930. Length, 362 mm.

Two adult females, Meru, May 26, 1930. Lengths, 190 mm. and 201 mm., respectively. "Iris dark brown; eyelids windsor blue; bill cadet gray; legs and feet, payne gray."

Juvenile, unsexed, Crater Lake, March 17, 1930. Length, 175 mm. "Iris dark brown."

All but the second female and the immature bird are in process of molt.

The reason for the use of the generic name *Terpsiphone* instead of *Tchitrea* was a long time ago explained by Doctor L. Stejneger.[1]

[1]Proc. U. S. Nat. Mus., Vol. XXXVII, No. 1721, August 4, 1910, p. 652.

Family TURDIDAE

Turdus olivaceus elgonensis (Sharpe)

Merula elgonensis SHARPE, The Ibis, Ser. 6, Vol. III, No. 11, July, 1891, p. 445 ("Mt. Elgon" [type from Kikuyu]).

Two specimens:

Adult male, Meru, May 26, 1930. Length, 230 mm. "Iris hazel; bill and legs, mikado orange; feet mikado orange, washed with raw sienna."

Juvenal male, Gunga Lake, May 22, 1930. Length, 243 mm. "Iris brown; bill mars yellow; legs and feet, orange citrine."

Petrophila rufocinerea rufocinerea (Rüppell)

Saxicola rufocinerea RÜPPELL, Neue Wirbelth. Fauna Abyss., Vögel, 1837, p. 76, pl. XXVII ("Simen" [Province,Ethiopia]).

One adult male, from Mount Kulal, April 4, 1930. Length, 171 mm. "Iris dark brown; bill and feet, black."

The relatively long wings easily separate the genus *Petrophila* from *Monticola*, even though the former is not recognized by some recent authors.

Oenanthe oenanthe oenanthe (Linnaeus)

[*Motacilla*] *Oenanthe* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 186 ("Europae" [restricted type locality, Sweden]).

Two specimens:

Adult female, Koroli, March 26, 1930. Length, 163 mm. "Bill, legs, and feet, black."

Adult, no indication of sex, Archer's Post, February 26, 1930.

Cichladusa guttata guttata (Heuglin)

Crateropus guttatus HEUGLIN, Journ. f. Ornith., Vol. X, No. 4, July, 1862, p. 300 ("Mittleren Lauf des Bahr el abiad" [upper White Nile; type from Aniop, Bahr el Jebel]).

Three specimens, from Lasamis:

Adult male, April 24, 1930.

Adult male, April 25, 1930. Length, 195 mm. "Iris hazel; bill black; legs and feet, chaetura black."

Adult male, March 13, 1930. Length, 168 mm. "Iris dark brown; legs and feet, blackish brown."

Family SYLVIIDAE

Erythropygia leucoptera leucoptera (Rüppell)

Salicaria leucoptera RÜPPELL, Syst. Uebers. Vögel Nord-Ost-Afr., 1845, p. 38, pl. XV ("Shoa").

A single adult male, from Merile, April 27, 1930. Length, 167 mm.

The genus *Erythropygia* has scutellate tarsi and therefore seems out of place in the family Turdidae. It apparently is better placed in the Sylviidae.

Acrocephalus scirpaceus scirpaceus (Hermann)

Turdus scirpaceus HERMANN, Observ. Zool., March, 1804, p. 202 (Alsace).

One adult male, from Koroli, March 24, 1930. Length, 142 mm. "Legs olive brown; feet dark olive buff."

Calamonastes simplex simplex (Cabanis)

Thamnobia simplex CABANIS, Journ. f. Ornith., Vol. XXVI, No. 2, April, 1878, p. 205 ("Ost-Afrika" [=Ndi, Teita district, Kenya Colony]).

One adult female, Archer's Post, February 26, 1930. Length, 125 mm. "Iris brown."

Apalis melanocephala nigrodorsalis Granvik

Apalis melanocephala nigrodorsalis GRANVIK, Journ. f. Ornith., Vol. LXXI, Sonderheft, February 15, 1923, p. 244 ("Kiambu" [near Nairobi]).

One adult male, from Meru, taken, May 29, 1930. Length, 145 mm. "Iris maroon; bill black; legs and feet, benzo brown."

This is a rare bird, which has been recorded apparently from only 2 localities, both in Kenya.

Sylvietta brachyura leucopsis (Reichenow)

Sylviella leucopsis REICHENOW, Ornith. Centralbl., Vol. IV, No. 15, August 1, 1879, p. 114 ("Kibaradja" [Tana River, Kenya Colony]).

One adult male, from Archer's Post, February 28, 1930. Length, 90 mm.

Eremomela griseoflava flavicrissalis Sharpe

Eremomela flavicrissalis SHARPE, Proc. Zool. Soc. London, Vol. for 1895, No. 3, October 1, 1895, p. 481 ("Shebeli" [western Somaliland]).

One adult male, from Koroli, April 16, 1930. Length, 86 mm. "Iris light brown; bill, legs, and feet, benzo brown."

It shows evidence of molt.

Cisticola cinereola schillingsi Reichenow

Cisticola schillingsi REICHENOW, in Schillings, mit Blitzlicht und Büchse, Thierw. Äquatorial-Ostafrika, Anhang, 1905, p. 556 ("Ngaptuk und Dönje Erok" [type locality, Doinyo Erok, Kenya Colony]).

One adult male, taken on Mount Kulal at 5500 feet altitude, April 5, 1930. Length, 147 mm.

Family CAMPEPHAGIDAE

Campephaga quiscalina münzneri Reichenow

Campephaga quiscalina münzneri REICHENOW, Ornith. Monatsb., Vol. XXIII, No. 6, June 15, 1915, p. 91 ("Mahenge in Deutsch-Ostafrika" [=Tanganyika Territory]).

One adult male, from Meru, May 26, 1930. Length, 197 mm. "Iris very dark brown; bill, legs, and feet, black."

This individual is in process of molt.

The present bird is commonly considered a subspecies of *Campephaga quiscalina*, but it is possibly a distinct species. Apparently it has not hitherto been recorded from Kenya.

Coracina caesia pura (Sharpe)

Graucalus purus SHARPE, The Ibis, Ser. 6, Vol. III, No. 9, January, 1891, p. 121 ("Mount Elgon").

Two specimens:

Adult male, Meru, May 26, 1930. Length, 242 mm. "Iris very dark brown; bill and feet, black."

Adult male, Gunga Lake, May 24, 1930. Length, 240 mm. "Iris dark brown; bill and feet, black."

Both of these birds are in process of molt of both contour feathers and quills.

Family DICRURIDAE

Dicrurus adsimilis divaricatus (Lichtenstein)

Muscicapa divaricata LICHTENSTEIN, Verz. Doubl. Zool. Mus. Berlin, 1823, p. 52 (Senegambia).

Three specimens:

Adult male, Kinya, May 2, 1930. Length, 220 mm. "Iris nopal red."

Adult female, Archer's Post, February 26, 1930. Length, 219 mm. "Iris carmine."

Immature female, Archer's Post, February 26, 1930. Length, 210 mm. "Iris light blue."

The two females are both in process of molt.

Family PRIONOPIDAE

Eurocephalus ruppelli ruppelli Bonaparte

E[urocephalus]. ruppelli BONAPARTE, Rev. et Mag. Zool., Ser. 2, Vol. V, No. 9, October, 1853, p. 440 ("Nilo albo, Schoa").

Three specimens, from Kisima Kufuta:

Adult female, May 6, 1930. Length, 226 mm. "Iris brown; bill, legs, and feet, black."

Two adult females, May 8, 1930. Lengths, 220 and 222 mm., respectively. "Iris hazel; bill slate black; legs and feet, slate gray."

Nilaus brubru minor Sharpe

Nilaus minor SHARPE, Proc. Zool. Soc. London, Vol. for 1895, No. 3, October 1, 1895, p. 479 ("Milmil; Sibbe; The Haud; Okoto" [type from Okoto, western Somaliland]).

Five specimens:

Adult male, Lasamis, April 22, 1930.

Adult female, Lasamis, April 23, 1930.

Immature female, Balessa, April 8, 1930. Length, 138 mm. "Iris brown, legs and feet, deep green blue gray."

Immature female, Archer's Post, February 26, 1930. Length, 137 mm. "Iris brown; legs and feet, slate."

Immature, sex unknown, Archer's Post, February 26, 1930. Length, 140 mm.

The 3 immature individuals are in process of molt from the juvenal to the first winter plumage. They resemble the adult female, but differ in having the pileum finely spotted with buff or buffy white; the white collar on the hind neck and the other white markings of the upper surface mixed with buff; the lower surface and the superior median coverts more or less barred with fuscous.

Also, the two adults show some indications of molt.

This helmet shrike is without much doubt specifically distinct from *Nilaus afer*, although by some authors treated as a race of that species. It seems, on the other hand, however, to be a subspecies of *Nilaus brubru*.

Family LANIIDAE

Lanius minor Gmelin

[*Lanius*] *minor* GMELIN, Syst. Nat., Vol. I, Part i, 1788, about July 1, p. 308 ("Italia, Hispania, Russia" [type locality, Italy]).

A single adult male, obtained at Lasamis on April 22, 1930, is in the collection.

Lanius collaris humeralis Stanley

Lanius humeralis STANLEY, in Salt, Voyage Abyssinia, Appendix IV, 1814, p. li ("Chelicut" [Abyssinia]).

Six specimens:

Adult male, Crater Lake, March 19, 1930. Length, 210 mm. "Iris brown; bill and feet, black."

Immature male, Crater Lake, March 19, 1930. Length, 210 mm.

Immature male, Gunga Lake, May 23, 1930.

Adult male, Gunga Lake, May 23, 1930.

Two adult females, Gunga Lake, May 25, 1930. Lengths, 224 and 225 mm., respectively.

All these are in process of molt. The two immature males are molting from the juvenal into the first winter plumage.

[Our specimens from Crater Lake were collected as they sat on dry bushes near the rushes of the lake.—A. B. F.]

Lanius somalicus somalicus Hartlaub

Lanius somalicus HARTLAUB, The Ibis, Ser. 1, Vol. I, No. 4, October, 1859, p. 342 ("near Bender Gam, in the country of the Ker-Singeli-Somals" [Red Sea]).

Two specimens, from Koroli:

Adult male, March 26, 1930. Length, 212 mm. "Bill, legs, and feet, black."

Juvenal male, April 15, 1930. Length, 216 mm. "Iris brown; upper mandible fuscous, lower mandible fuscous on terminal half, passing into smoke gray at base."

The second bird is beginning to molt into the first winter plumage.

Lanius dorsalis Cabanis

Lanius (*Fiscus*) *dorsalis* CABANIS, Journ. f. Ornith., Vol. XXVI, No. 2, April, 1878, pp. 205, 225 ("Ost-Afrika" [=Ndi, Kenya, Colony]).

Seven specimens:

Adult male, Kisima Kufuta, May 6, 1930. Length, 217 mm. "Iris hazel; bill and feet, black."

Adult male, Kisima Kufuta, May 10, 1930. Length, 221 mm.

Adult female, Kisima Kufuta, May 12, 1930. Length, 222 mm.

Adult male, Kinya, May 1, 1930. Length, 224 mm.

Adult female, Kinya, May 1, 1930. Length, 215 mm.

Immature male, Archer's Post, February 27, 1930. Length, 210 mm. "Iris brown."

Immature male, Archer's Post, February 28, 1930. Length, 198 mm.

The two immature birds are just completing the post-juvenal molt. The adult male from Kinya and the first Kisima Kufuta male also show indications of molt.

Family LANIARIIDAE

Laniarius ferrugineus ambiguus Madarász

Laniarius ambiguus MADARÁSZ, Ann. Mus. Nat. Hung., Vol. II, Part 1, June 25, 1904, p. 205 ("Kiboscho und Moschi" [type locality, Kiboscho, Kilimanjaro]).

Two specimens, from Gunga Lake, obtained on May 25, 1930:

Adult male. Length, 218 mm.

Immature male. Length, 236 mm.

Laniarius nigrifrons nigrifrons Reichenow

Laniarius nigrifrons REICHENOW, Ornith. Monatsb., Vol. IV, No. 6, June, 1896, p. 95 ("Marangu am Kilimandjaro").

One adult female, Gunga Lake, May 28, 1930. Length, 195 mm. "Iris ox-blood red; bill black; legs and feet, light payne gray."

There seem to be no trenchant structural characters to separate from *Laniarius* the group of species currently considered to represent the genus *Chlorophoneus*. Such as have been assigned appear totally to disappear when intermediate species are examined. The present species should therefore be referred to *Laniarius*.

Dryoscopus cubla hamatus Hartlaub

Dryoscopus hamatus HARTLAUB, Proc. Zool. Soc. London, Vol. for 1863, No. 2, August 1, 1863, p. 106 ("Kazeh" [Victoria Nyanza]).

Two specimens, from Gunga Lake, collected, May 21, 1930:

Adult male. Length, 180 mm. "Iris scarlet; bill black; legs and feet, clear payne gray."

Nearly adult female. Length, 185 mm. "Iris deep mouse gray; bill black; legs and feet, clear payne gray."

Both these birds show evidence of molt. The female is in the plumage preceding the adult stage, the jugulum, upper breast, sides of neck, and scapulars being strongly suffused with buff, which color somewhat tinges also the sides.

Pomatorhynchus australis littoralis (Van Someren)

Harpolestes australis littoralis VAN SOMEREN, Bull. Brit. Ornith. Club, Vol. XLI, No. CCLVIII, April 1, 1921, p. 102 ("Changamwe" [Kenya Colony]).

One adult female, from Gunga Lake, May 20, 1930. Length, 192 mm.

This specimen shows some molt of both wing quills and contour feathers. It represents apparently an extension of the known range of the subspecies, since this seems not to be known northwest of the Tana River.

Rhodophoneus cruentus hilgerti (Neumann)

Pelicinius cruentus hilgerti NEUMANN, Ornith. Monatsb., Vol. XI, No. 12, December, 1903, p. 182 ("Shiekh Hussein" [Somaliland]).

Two specimens, from Kisima Kufuta, collected on May 10, 1930:

Adult female. Length, 242 mm. "Iris brown; bill black."

Juvenal female. Length, 256 mm.

The latter example is molting from the juvenal into the first winter plumage. It still retains the buff edgings on the wings and the narrow pale buff tips on the feathers of the occiput and hind neck, which impart an obsolescently barred effect.

The adult female is also in process of molt.

Family PARIDAE

Parus afer barakae Jackson

Parus barakæ JACKSON, The Ibis, Ser. 7, Vol. V, No. 4, October, 1899, p. 639 ("Njemps" [near Lake Baringa, Kenya Colony]).

One adult male, from Mount Kulal, April 6, 1930. Length, 130 mm. "Iris brown; legs and feet, slate gray."

Some of the wing quills and tail feathers are in molt.

[The only individual noted was a specimen from Mount Kulal. It was collected in some thorn trees about 20 feet tall near the base of a sheer cliff near our camp at an altitude of about 5000 feet. Its note was very similar to that of the black-capped chickadee (*Parus atricapillus atricapillus*) of Ohio.—A.B.F.]

Family ORIOLIDAE

Oriolus monacha percivali Ogilvie-Grant

Oriolus percivali OGILVIE-GRANT, Bull. Brit. Ornith. Club, Vol. XIV, No. C, October 30, 1903, p. 18 ("Kikuyu").

Five specimens:

Adult male, Gunga Lake, May 28, 1930. Length, 238 mm. "Iris ox-blood red; bill deep brownish vinaceous, darker at tip; legs and feet, deep neutral gray."

Adult female, Gunga Lake, May 28, 1930. Length, 220. "Iris ox-blood red; bill deep brownish vinaceous, darker at tip; legs and feet, deep plumbeous."

Adult female, Meru, May 29, 1930. Length, 230 mm.

Adult male, Meru, May 29, 1930. Length, 235 mm.

Immature male, Meru, May 29, 1930. Length, 208 mm.

All are in process of molt of either quills or contour feathers, or both. The immature example differs from the adults in more greenish (less yellowish) upper surface; less clearly yellow (more greenish) lower parts; dark blackish brown, yellowish olive streaked, instead of black, pileum; and olive yellow chin and throat much streaked and spotted with blackish brown, instead of solidly black. The bill is dark colored, somewhat blackish.

This bird is apparently a species distinct from all others except *Oriolus monacha*, with which it apparently intergrades. The black central tail feathers are not a feature of age, as the immature examples show it practically as well as do adults.

In view of these circumstances and others that J. P. Chapin has detailed[1], it appears that he is correct in considering this oriole a highland race of *Oriolus monacha*.

Family CORVIDAE

Corvus corax edithae Phillips

Corvus edithæ PHILLIPS, Bull. Brit. Ornith. Club, Vol. IV, No. XXVII, May 31, 1895, p. 36 ("Somaliland" [Hainwaina Plain]).

Five specimens:

Adult male, Lasamis, March 13, 1930. Length, 483 mm. "Iris blue black; bill, legs, and feet, black."

Two adult females, Lasamis, March 13, 1930. Lengths, 438 and 457 mm., respectively. "Iris blue black; bill, legs, and feet, black."

[1]The Auk, Vol. LXI, No. 1, January, 1944, pp. 289-291.

Adult, sex not indicated, Lasamis, March 13, 1930. Length, 470 mm. "Iris blue black; bill, legs, and feet, black."

Adult female, Koroli, March 25, 1930. Length, 445 mm.

These specimens extend the range of this raven for some distance southeast from the southern end of Lake Rudolf, the nearest locality at which it apparently previously has been taken. The bird from Koroli is in molt.

Corvultur albicollis (Latham)

[*Corvus*] *albicollis* LATHAM, Index Ornith., Vol. I, 1790, p. 151 ("Africa?" [type locality restricted to Cape Town by Meinertzhagen[1]]).

Two specimens:

Adult male, Mount Kulal, altitude about 6000 feet, April 2, 1930. Length, 578 mm.

Adult male, Gunga Lake, May 27, 1930. Length, 546 mm.

Rhinocorax rhipidurus (Hartert)

Corvus rhipidurus HARTERT, Bull. Brit. Ornith. Club, Vol. XXXIX, No. CCXXXVII, November 30, 1918, p. 21 (new name for *Corvus affinis* Rüppell).

Three specimens:

Adult female, Archer's Post, February 25, 1930. Length, 470 mm.

Adult female, Lasamis, March 14, 1930. Length, 461 mm.

Adult male, 1930. (No further data).

Family STURNIDAE

Creatophora cinerea (Meuschen)

Rallus cinereus MEUSCHEN, Museum Geversianum, 1787, p. 40, No. 17 (no locality [type locality, Cape of Good Hope]).

Thirteen specimens:

Adult male, Kisima Kufuta, May 6, 1930. Length, 232 mm. "Iris brown; bare cheeks and top of head, lemon chrome; bill pale ochraceous buff; wattles and bare throat, black; front of tarsus bone brown; feet brownish drab."

Adult female, Kisima Kufuta, May 6, 1930. Length, 223 mm. "Iris dark brown; bare space around eyes lemon yellow; bill pale ochraceous buff; legs and feet, brownish drab."

Adult male, Kisima Kufuta, May 6, 1930. Length, 231 mm.

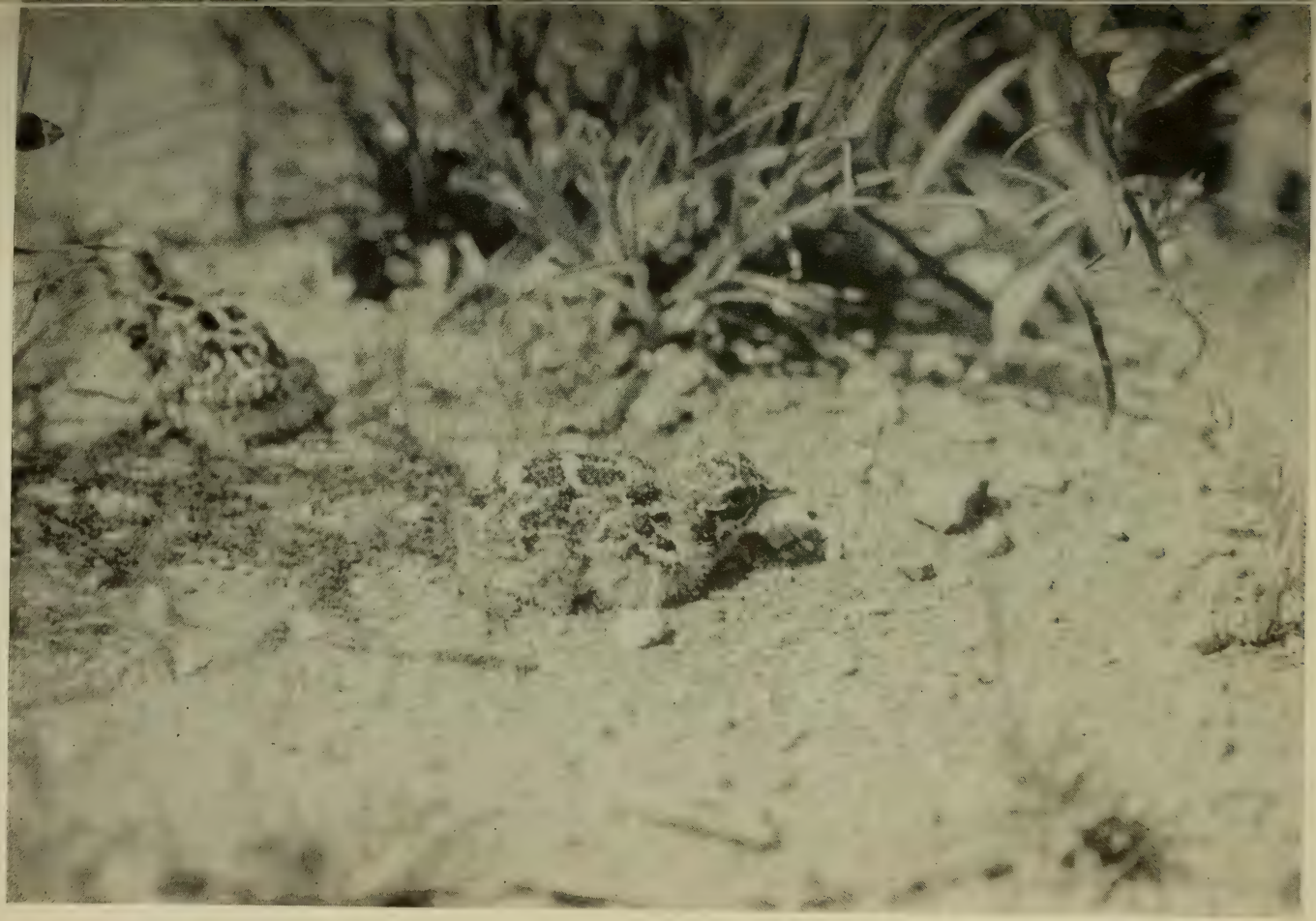
Adult female, Kinya, May 2, 1930. Length, 220 mm.

Adult male, Koroli, March 24, 1930. Length, 230 mm.

Adult male, Koroli, March 24, 1930. Length, 224 mm.

Adult male, Koroli, March 24, 1930. Length, 225 mm. "Iris brown; bare skin around eye lemon chrome; bill pale drab gray; bare throat spaces black; legs and feet, bone brown."

[1]Novit. Zool., Vol. XXXIII, No. 2, October 20, 1926, p. 96.



YOUNG SOMALILAND SAND GROUSE *(Pterocles exustus somalicus)* TRUSTING TO THEIR PROTECTIVE COLORATION TO HIDE THEM, AT KOROLI. April 18, 1930.

Storehouse for Specimens at Base Camp, Archer's Post. The Nests in the Tree above Are Those of the Donaldson Sparrow-Weaver (*Fullerellus donaldsoni*). February 2, 1930.

Adult female, Koroli, March 24, 1930. Length, 223 mm. "Iris dark brown; bare skin posterior to eye chalcedony yellow."

Adult female, Koroli, March 24, 1930. Length, 224 mm. "Bill pale gray with a lavender tint."

Four adult females, from Koroli, taken, March 24, 1930. Lengths, respectively, 218, 219, 222, and 228 mm.

The first-listed example from Kisima Kufuta is entirely bare-headed and has fully developed wattles. The first Koroli male has fairly well developed wattles, and the head nearly all bare of feathers excepting the forehead. The second male from Koroli has the head feathered except for the postocular and subocular regions, and has partly developed throat wattles, and a small wattle among the feathers of the fore part of the crown. On the throat of the second-listed female from Koroli the throat wattles are just beginning to develop. In most of the females from Koroli the ovaries were swollen on March 24.

[At Koroli this starling was very common in pairs and in flocks of from 3 to 50. Restless and hard to kill, these birds seem to be the counterpart of *Sturnus vulgaris*. In March, during our first visit to Koroli, we found them passing up and down a wet water-course, altogether hundreds of them, and about equal numbers were passing simultaneously in each direction. Occasionally they would swarm into a shrub, chatter a minute or two, then continue on their course.—A. B. F.]

Speculipastor bicolor Reichenow

Speculipastor bicolor REICHENOW, Ornith. Centralbl., Vol. IV, No. 14, July 15, 1879, p. 108 ("Kipini" [Kenya Colony]).

Three specimens, from Kisima Kufuta:

Male, nearly adult, May 13, 1930. Length, 225 mm. "Iris orange chrome; bill, legs, and feet, black."

Female, nearly adult, May 13, 1930. Length, 204 mm. "Iris orange; bill, legs, and feet, black."

Immature male, May 12, 1930. Length, 206 mm. "Iris hazel; bill, legs, and feet, black."

The first-mentioned male is molting into the adult plumage, this involving rectrices, wing quills, and contour feathers.

The female is likewise involved in molt into the adult plumage.

The immature example is in the first winter livery, but shows some indications of feather change.

Lamprocolius corruscus jombeni Van Someren

Lamprocolius curruscus jombeni VAN SOMEREN, Journ. East Afr. and Uganda Nat. Hist. Soc., No. 37, January, 1930, p. 197 ("Jombeni, N.E. of Mt. Kenia").

A single adult male, from Gunga Lake, May 22, 1930. Length, 225 mm. "Iris cadmium yellow."

This individual is in process of molt of the rectrices and con-

tour feathers.

Like other Kenya specimens this one is smaller than typical examples, but is nevertheless too large to be referred to *Lamprocolius corruscus mandanus*.

Cosmopsarus regius magnificus Van Someren

Cosmopsarus regius magnificus VAN SOMEREN, Bull. Brit. Ornith. Club, Vol. XLIV, No. CCLXXXVI, March 31, 1924, p. 71 ("Tsavo" [Kenya Colony]).

Nine specimens:

Adult male, Kisima Kufuta, May 7, 1930. Length, 323 mm. "Iris ivory yellow; bill, legs, and feet, black."

Adult male, Kisima Kufuta, May 7, 1930. Length, 335 mm. "Iris ivory yellow; bill, legs, and feet, black."

Immature female, Kisima Kufuta, May 8, 1930. Length, 256 mm. "Iris ivory yellow; bill and feet, black."

Adult female, Kisima Kufuta, May 9, 1930. Length, 311 mm.

Adult male, Kisima Kufuta, May 9, 1930. Length, 319 mm.

Immature female, Kisima Kufuta, May 9, 1930. Length, 298 mm.

Immature male, Kinya, May 2, 1930. Length, 321 mm. "Iris grayish olive; gape primuline yellow; bill, legs, and feet, black."

Immature male, Kinya, May 1, 1930.

Immature female, Kinya, May 1, 1930. Length, 285 mm. "Iris brown."

All these show some indication of molt among either wing quills or contour feathers, in some cases both. The two immature females from Kisima Kufuta are molting from the immature into the adult plumage. The 3 from Kinya are in what is apparently the first winter dress, with dull brown head and throat.

Pyrrhocheira walleri walleri (Shelley)

Amydrus walleri SHELLEY, The Ibis, Ser. 4, Vol. IV, No. 15, July, 1880, p. 335, pl. VIII ("Usambara Mountains").

One adult male, Meru, May 26, 1930. Length, 263 mm. "Iris dark brown; bill, legs, and feet, black."

This example shows some evidences of molt of the contour feathers.

The genus *Pyrrhocheira* Reichenbach, though by some recent authors merged with *Onychognathus*, differs enough structurally to warrant its separation. The tail is nearly square or only slightly rounded, the difference between the longest and shortest rectrices being less than the length of the tarsus; while in *Onychognathus* the tail is strongly graduated or even wedge-shaped, with the difference between the longest and shortest rectrices exceeding the length of the tarsus.

Stilbopsar kenricki (Shelley)

Pœoptera kenricki SHELLEY, Bull. Brit. Ornith. Club, Vol. III, No. XVIII, May 26, 1894, p. 42 ("Usambara Mts." [Tanganyika Territory]).

Two specimens, from Gunga Lake, May 22, 1930:

Adult male. Length, 222 mm. "Iris light cadmium."

Adult female. Length, 215 mm. "Iris light cadmium."

Previous records of this starling are few and represent only about 3 localities, from the Usambara Mountains to Mount Kilimanjaro and the region about Mount Kenya.

Lamprospreo superbus (Rüppell)

Lamprotornis superbus RÜPPELL, Syst. Uebers. Vögel Nord-Ost-Afr., 1845, p. 65, pl. XXVI ("Shoa" [Abyssinia]).

Eleven specimens:

Adult male, Kisima Kufuta, May 13, 1930. Length, 205 mm. "Iris cream buff; bill, legs, and feet, black."

Immature male, Kisima Kufuta, May 11, 1930. Length, 206 mm. "Iris dark brown; bill and feet, black."

Male, nearly adult, Kinya, April 30, 1930. Length, 193 mm.

Adult female, Lasamis, April 24, 1930.

Two adult males, Lasamis, April 23, 1930.

Adult male, Archer's Post, February 25, 1930. Length, 203 mm. "Iris pale yellow; legs and feet, black."

Adult male, Archer's Post, February 26, 1930. Length, 187 mm. "Iris ivory yellow."

Adult male, Archer's Post, March 6, 1930. Length, 192 mm. "Iris light brown."

One immature male and 1 immature female, from Archer's Post, April 25, 1930.

All these examples show some indication of molt among contour or other feathers, although this is slight in some of the immature birds. The male from Kinya is changing from immature into adult plumage. The other immatures differ from the adults in their much less glossy upper surface, excepting the wings; in the dark brown only slightly glossy anterior lower parts, and in the lighter, ochraceous tawny instead of deep orange rufous posterior portions.

The present species, together with *Spreo pulcher* (Müller), have been generically separated from the remaining forms of the genus Spreo under the name *Lamprospreo* Roberts[1], and later *Painterius* Oberholser[2]. This group differs sufficiently in structural characters to warrant such a division. As thus constituted, the genus *Lamprospreo* differs from *Spreo* in several important respects. The palate just anterior to the angle of the gonys is smooth instead of ridged; the exposed culmen is equal to the hind toe with claw (instead of

[1]Ann. Transvaal Mus., Vol. VIII, No. 4, October 30, 1922, p. 272 (in text).

[2]Scient. Publ. Cleveland Mus. Nat. Hist., Vol. I, No. 3, September 30, 1930, p. 81 (type, *Lamprotornis superbus* Rüppell).

much shorter); 5 (instead of 4) primaries are sinuate on the outer webs; the notch on the inner webs of the primaries is conspicuous; counting from the outermost primary, the 4th, or 4th and 5th (instead of the 3rd) are longest, and the 2nd is shorter, instead of longer, than the 5th; the feet reach to the end of the tail, which is relatively shorter and much less strongly rounded; also the lower tail-coverts are relatively longer as compared with the length of the tail.

Buphagus erythrorhynchus erythrorhynchus (Stanley)

Tanagra erythrorhyncha STANLEY, in Salt, Voyage Abyssinia, Appendix IV, 1814, p. lix ("Abyssinia").

A single adult female, collected at Archer's Post, February 28, 1930. Length, 229 mm. "Iris flame scarlet; eyelids cadmium; bill scarlet red; legs and feet, deep brownish drab."

This specimen is in progress of molt of both wing quills and contour feathers.

[The only specimen was obtained at Archer's Post near the small marsh a short distance from our camp.—A.B.F.]

Family NECTARINIIDAE

Cinnyris venustus blicki Mearns

Cinnyris venusta blicki MEARNS, Proc. U. S. Nat. Mus., Vol. XLVIII, No. 2076, January 19, 1915, p. 386 ("near the south shore of Lake Stephanie, in northern British East Africa").

Two specimens:

Adult male, Lasamis, March 13, 1930. Length, 102 mm. "Iris dark brown; bill, legs, and feet, black."

Adult male, Kinya, April 30, 1930. Length, 109 mm. "Iris brown."

Drepanorhynchus kilimensis kilimensis (Shelley)

Nectarinia kilimensis SHELLEY, Proc. Zool. Soc. London, Vol. for 1884, No. 4, April 1, 1885, p. 555 ("Kilimanjaro, 5000 ft." [Tanganyika Territory]).

One adult male, from Gunga Lake, May 20, 1930. Length, 184 mm.

Although commonly placed in the genus *Nectarinia*, the very much curved bill and the narrow V-shaped bare area parting the feathers of the forehead are structural characters justifying the reference of this species to the genus *Drepanorhynchus*[1] of which *Drepanorhynchus reichenowi* is the type.

Anthreptes orientalis orientalis Hartlaub

Anthreptes orientalis HARTLAUB, Journ. f. Ornith., Vol. XXVIII, No. 2, April, 1880, p. 213 ("Lado" [upper Nile]).

Three specimens, all from Balessa:

[1]Fischer and Reichenow, Journ. f. Ornith., Vol. XXXII, No. 1, January, 1884, p. 56.

Adult male, March 31, 1930. Length, 127 mm. "Iris brown; bill blackish brown No. 1; legs and feet, black."

Adult female, April 8, 1930. Length, 122 mm.

Juvenal male (?), April 8, 1930. Length, 130 mm. "Legs and feet, deep neutral gray."

The immature example is similar to the adult female but has the lower surface washed with primrose yellow. It is in process of molt.

Family PLOCEIDAE

Bubalornis albirostris intermedius (Cabanis)

Textor intermedius CABANIS, Journ. f. Ornith., Vol. XVI, No. 6, November, 1868, p. 413 ("Ost-Afrika" [type locality, Kisuani, Usambara district, Tanganyika Territory]).

Six specimens:

Adult male, Koroli, April 17, 1930. Length, 242 mm. "Iris brown; bill nopal red; legs and feet, buffy brown."

Immature male, Koroli, April 17, 1930. Length, 199 mm. "Iris deep mouse gray; bill ochraceous buff at tip, mummy brown at base; legs and feet, light neutral gray."

Adult male, Lasamis, April 24, 1930.

Three immature males, from Lasamis, collected on April 24, 1930.

The adult male from Lasamis shows some molting wing quills, and 2 of the immature males from Lasamis are in process of molt from the juvenal plumage.

Dinemellia dinemelli dinemelli (Gray)

Textor dinemelli (HORSFIELD MS.) GRAY, Genera Birds, Part 1, May, 1844, Vol. II, p. [350] pl.- (No locality; type locality, Shoa, *fide* Rüppell, Syst. Uebers. Vögel Nord-Ost-Afr., 1845, pp. 72, 76).

Four specimens:

Adult male, Koroli, March 26, 1930. Length, 211 mm. "Iris brown, with an outer ring of ivory yellow; bare skin around eye black; bill, legs, and feet, blackish brown."

Adult female, Koroli, March 26, 1930. Length, 202 mm. "Iris with outer ring ivory yellow; bare skin around eye blackish brown; bill, legs, and feet, brown."

Adult male, Koroli, April 17, 1930. Length, 206 mm. "Iris brown; bare skin around eyes, with bill and legs, fuscous."

Adult male, Lasamis, April 23, 1930.

All show indications of molt among the wing quills.

Plocepasser mahali melanorhynchus Bonaparte

P[locepasser]. melanorhynchus BONAPARTE, Consp. Gen. Avium, Vol. I, Part 2, about February 3, 1851, p. 444 ("Schoa").

Six specimens:

Adult male, Balessa, March 31, 1930. Length, 184 mm. "Iris maroon; legs and feet, russet vinaceous."

Two adult males, Archer's Post, March 6, 1930. Lengths, 164 and 162 mm., respectively. "Iris dark brown."

Adult male, Lasamis, April 22, 1930.

Adult male, Kinya, May 2, 1930. Length, 182 mm.

Adult female, Kinya, May 2, 1930. Length, 182 mm.

All these specimens show indication of molt, chiefly among the wing feathers and rectrices.

Fullerellus, gen. nov.[1]

Diagnosis.—Differs from the genus *Plocepasser* Smith, by reason of its decidedly shorter tail, this less than two-thirds the length of the wing instead of seven-tenths; bill longer and relatively more slender, its height at base not more than half the length of exposed culmen, its width at base only two-fifths instead of one-half the length of the exposed culmen; exposed culmen nine-tenths of the length of the tarsus; outstretched feet reaching very nearly or quite to the end of the tail, falling short, if at all, by much less than half the length of the tarsus, instead of falling far short; first (outermost) primary narrower and more pointed, much less than one-third the length of the second primary, instead of equal to or more than one-third the length of the second; second primary equal to or longer than the fourth, instead of shorter than the fourth; 5 instead of 6 primaries sinuate on outer webs.

Type.—Ploceipasser donaldsoni Sharpe.

Remarks.—The very distinct *Plocepasser donaldsoni* is so peculiar in its structural characters that it seems out of place in the genus *Plocepasser,* and merits removal to another generic group.

Since all the generic names based on species now in the genus *Plocepasser* are synonyms of this, there remains to be provided a new generic term for *Plocepasser donaldsoni.* In view of this it seems desirable to recognize Mr. Arthur B. Fuller's many and important contributions to the progress of the Cleveland Museum of Natural History by giving his name to this new genus.

Fullerellus donaldsoni (Sharpe)

Ploceipasser donaldsoni SHARPE, Bull. Brit. Ornith. Club, Vol. V, No. XXXI, December 20, 1895, p. 14 ("Eastern Africa" [=near Lasamis]).

Eleven specimens:

Adult male, Lasamis, April 20, 1930. Length, 163 mm. "Iris sorghum brown; bill black; legs and feet, light mouse gray."

Adult male, Lasamis, April 20, 1930. Length, 162 mm. "Iris nopal red; bill black; legs and feet, light vinaceous fawn."

[1]Named for Arthur Bennett Fuller, the naturalist of the White-Fuller Expedition, who collected most of the birds.

Adult male, Lasamis, April 20, 1930. Length, 169 mm. "Iris nopal red; bill black; legs and feet, vinaceous fawn."

Adult female, Lasamis, April 20, 1930. Length, 172 mm. "Iris sorghum brown; bill black; legs and feet, pale drab gray."

Adult male, Koroli, March 26, 1930. Length, 161 mm. "Iris carmine; bill black; legs and feet, avellaneous touched with vinaceous fawn."

Adult male, Archer's Post, March 6, 1930. Length, 159 mm. "Eyelids scarlet."

Adult female, Archer's Post, March 6, 1930. Length, 170 mm. "Iris dark brown."

Adult female, Archer's Post, February 28, 1930. Length, 165 mm. "Iris red."

Adult male, Kisima Kufuta, May 11, 1930. Length, 157 mm.

Adult male, Kisima Kufuta, May 11, 1930. Length, 156 mm.

Adult female, Kisima Kufuta, May 11, 1930. Length, 156 mm.

The 4 specimens of this little known weaver bird from Lasamis are of course virtual topotypes, but they differ in no respect from the others. The 3 birds from Kisima Kufuta taken in May are apparently beginning to molt.

[At Archer's Post, February 23, some of these weaver birds had hung their nests in the thorn trees over our tents, and with their warbling chirrups serenaded us almost constantly, even during the night.—A.B.F.]

Whitellus, gen. nov.[1]

Diagnosis.—Similar to *Pseudonigrita* Reichenow, but tail much longer, nearly three-quarters (7/10) of the length of the wing, instead of barely more than one-half; bill much stouter, its height at base about three-quarters of the length of exposed culmen, instead of less than two-thirds, also broader at base; second primary (counting from the outermost) much narrowed on the terminal third of inner web, thus being there much narrower than the third primary, instead of just as wide; tertials in closed wing falling decidedly short of the tip of the seventh primary; feet falling short of the end of tail by at least half the length of the culmen, instead of reaching to or beyond the end of the tail.

Type.—*Nigrita cabanisi* Fischer and Reichenow.

Remarks.—The type of this new genus differs so much from the type of *Pseudonigrita, Pseudonigrita arnaudi* (Bonaparte), that its removal to a genus of its own seems desirable, as already suggested by at least one recent author, Frederick J. Jackson. No other species seem to be congeneric.

This new genus is very appropriately dedicated to Mr. Windsor T. White, who was the organizer and leader of the White-Fuller Expedition to East Africa in 1930, during which the specimens recorded in the present contribution were collected. He is one of the trustees of the Cleveland Museum of Natural History.

[1]Named in honor of Mr. Windsor T. White, of Cleveland, Ohio, the leader of the White-Fuller Expedition.

Whitellus cabanisi (Fischer and Reichenow)

Nigrita Cabanisi FISCHER and REICHENOW, Journ. f. Ornith., Vol. XXXII, No. 1, January, 1884, p. 54 ("Ebene am Pare-Gebirge" [Masai Land]).

Six specimens:

Two adult males, from Lasamis, April 20, 1930. Lengths, 125 and 135 mm., respectively. "Iris flame scarlet; base of bill naphthaline yellow, tip pale vinaceous fawn; legs and feet, vinaceous fawn."

Adult female, Lasamis, April 20, 1930. Length, 130 mm. Colors of unfeathered parts the same as those of the males above listed.

Adult male, Lasamis, March 13, 1930. Length, 138 mm. "Iris grenadine red; legs and feet, japan rose."

Two specimens from Kinya, April 30, 1930. Male, length, 135 mm., female, 135 mm.

Passer castanopterus fulgens Friedmann

Passer castanopterus fulgens FRIEDMANN, Occ. Papers Boston Soc. Nat. Hist., Vol. V, October 10, 1931, p. 428. ("Indunamara Mountains, Kenya Colony").

Five specimens, from Koroli:

Adult male, March 24, 1930. Length, 132 mm. "Legs and feet, honey yellow."

Adult male, April 17, 1930. Length, 131 mm. "Iris brown, bill black; legs and feet, avellaneous."

Adult female, April 17, 1930. Length, 131 mm. "Iris light brown; upper mandible natal brown, lower mandible light vinaceous fawn; legs and feet, wood brown."

Juvenal female, April 17, 1930. Length, 128 mm. "Iris brown; upper mandible natal brown, lower mandible light vinaceous fawn; legs and feet, buffy brown."

Juvenal male, April 17, 1930. Length, 132 mm.

The juvenal female is practically identical with the adult of the same sex. The juvenal male is similar, but has the pileum and hind neck more cinnamomeous.

Passer gongonensis (Oustalet)

Pseudostruthus gongonensis OUSTALET, Le Naturaliste, Ser. 2, Vol. XII, No. 90, December 1, 1890, p. 274 ("Gongoni" [near Mombasa]).

Thirteen specimens:

Adult male, Kinya, May 2, 1930. Length, 180 mm. "Iris burnt sienna; bill black."

Adult female, Kinya, May 4, 1930. Length, 180 mm.

Adult female, Merile, April 27, 1930. Length, 185 mm.

Immature, unsexed, Archer's Post, May 15, 1930. Length, 185 mm. "Iris brown; bill black; legs and feet, citrine drab."

Two immature males, Archer's Post, May 15, 1930. Lengths, 172 and 173, respectively.

Seven immature birds, without indication of sex, from Archer's Post, March 15-21, 1930.

All the immature birds are in process of molt.

Sorella eminibey Hartlaub

S[orella]. Emini Bey HARTLAUB, Journ. f. Ornith., Vol. XXVIII, No. 2, April, 1880, p. 211 ("Lado" [upper Nile]).

Four adult males:

Two from Kisima Kufuta, May 11, 1930. Lengths, 120 and 123 mm., respectively.

One from Merile, April 28, 1930. Length, 123 mm. "Iris saccardo umber; bill black; legs and feet, buffy brown."

One from Lasamis, April 20, 1930, Windsor T. White. Length, 119 mm. "Iris dark brown; bill black; legs and feet, pale verona brown."

Gymnoris pyrgita massaica Neumann

Gymnoris pyrgita massaica NEUMANN, Bull. Brit. Ornith. Club, Vol. XXI, No. CXLI, March 30, 1908, p. 70. ("Escarpment Station, Kikuyu" [Kenya Colony]).

One adult male, from Kinya, taken on April 30, 1930. Length, 160 mm.

Othyphantes reichenowi reichenowi (Fischer and Reichenow)

Sycobrotus Reichenowi (FISCHER MS.) FISCHER and REICHENOW, Journ. f. Ornith., Vol. XXXII, No. 2, April, 1884, p. 180 ("Gross-Aruscha, Naiwascha-See").

Three specimens:

Immature male, Crater Lake, March 19, 1930. Length, 164 mm. "Iris brownish olive; bill drab; legs and feet, light drab."

Immature female, Gunga Lake, May 28, 1930. Length, 169 mm. "Iris dark brown; upper mandible fuscous, lower mandible pale ecru drab; legs and feet, deep brownish drab."

Immature female, Gunga Lake, May 24, 1930. Length, 168 mm.

These young birds have the upper parts dull olive green, the back and scapulars broadly streaked with fuscous black. The lower surface is entirely yellow, that of the male more golden (less greenish), the jugulum and flanks tinged with ochraceous.

Phormoplectes insignis ornatus (Granvik)

Ploceus insignis ornatus GRANVIK, Ornith. Monatsb., Vol. XXX, No. 2, March 1, 1922, p. 40 ("Kiambu bei Nairobi").

One adult male, from Meru, collected on May 26, 1930. Length, 159 mm. "Iris pompeian red; bill black; legs and feet, natal brown." The contour feathers and some of the wing quills are in process of molt.

Textor cabanisii kisumui (Van Someren)

Hyphantornis intermedius kisumui VAN SOMEREN, Bull. Brit. Ornith. Club, Vol. XLI, No. CCLX, May 26, 1921, p. 122 ("Kisumu").

Three specimens, from Lasamis:

Adult male, April 21, 1930.

Adult male, April 25, 1930.

Adult female, April 25, 1930, with nest and 1 egg.

Since the generic name *Textor* Temminck, as hereinafter explained[1] should replace *Sitagra* Reichenbach, the specific name *intermedius* cannot be employed for the present species, because it would thus be preoccupied by *Textor intermedius* Cabanis[2], which is now *Bubalornis albirostris intermedius*. The oldest available specific name therefore becomes cabanisii Peters[3]. For the subspecies currently known as *Sitagra intermedia intermedia* there is available *Hyphantornis intermedius kisimui* Van Someren, which is apparently the same bird. This subspecies would therefore have the name *Textor cabanisii kisimui* (Van Someren).

Textor vitellinus uluensis (Neumann)

Hyphantornis vitellinus uluensis NEUMANN, Journ. f. Ornith., Vol. XLVIII, No. 3, July, 1900, p. 282 ("Ulu Berge" (i.e.,Machakos, Kenya Colony]).

Seven specimens:

Adult male, Kisima Kufuta, May 13, 1930. Length, 142 mm. "Iris cadmium orange; bill black; legs and feet, light grayish vinaceous."

Adult male, Kisima Kufuta, May 13, 1930. Length, 145 mm. "Iris scarlet; bill black; legs and feet, russet vinaceous."

Two adult males, from Merile, April 27, 1930. Lengths, 146 and 147 mm., respectively.

Adult male, Lasamis, April 20, 1930. Length, 151 mm. "Iris orange buff; bill black; legs and feet, brownish drab."

Adult female, Kinya, May 3, 1930. "Upper mandible pale clove brown; legs pale warm sepia."

Juvenal female, Kinya, May 3, 1930. Length, 137 mm. "Iris dark brown; upper mandible pale clove brown, lower mandible pale vinaceous fawn; legs and feet, light payne gray."

This juvenal female differs from the adult of the same sex in having the upper surface almost uniform olive green, with only obscure narrow dull brown shaft streaks on the back and scapulars; and the jugulum lacks ochraceous tinge, being almost clear wax yellow.

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[1] *Cf.* postea, pp. 117-118.

[2] Journ. f. Ornith., Vol. XVI, No. 6, November, 1868, p. 413.

[3] *Hyphantornis Cabanisii* Peters, Journ. f. Ornith., Vol. XVI, No. 2, March, 1868, p. 133 ("Inhambane").

Textor rubiginosus rubiginosus (Rüppell)

Ploceus rubiginosus RÜPPELL, Neue Wirbelth. Faun. Abyss., Vögel, 1835, p. 93, pl. XXXIII, fig. 1 (Temben, Abyssinia).

Eleven specimens:

Adult male, Merile, April 28, 1930. Length, 168 mm. "Iris brazil red; bill black; legs and feet, deep quaker drab."

Adult male, Merile, April 28, 1930. Length, 167 mm. "Iris brazil red; bill black; legs and feet, quaker drab."

Adult female, Merile, April 28, 1930. Length, 156 mm. "Iris nopal red; bill black; legs and feet, light quaker drab."

Two immature females, Merile, April 28, 1930. Lengths, 152 and 159 mm., respectively. "Iris brazil red; bill black; legs and feet, light quaker drab."

Two adult males, Lasamis, April 21 and 22, 1930.

Adult female, Lasamis, April 21, 1930.

Three adult males, Lasamis, April 21, 1930.

Of the examples listed above, the 2 adult males from Merile and the first 2 from Lasamis are in process of molt. The immature females are darker than adults, more richly rufescent above, and also on the jugulum and sides, with narrow indistinct fuscous shaft streaks on the feathers of the jugulum.

The generic name *Sitagra* Reichenbach, in use for the group to which the present species belongs whether employed in generic or subgeneric sense, should be replaced by *Textor* Temminck. This arises from the fact that Temminck first made use of *Textor* as a generic name for *Oriolus textor* Gmelin (=*Oriolus cucullatus* Müller =*Hyphantornis* vel *Sitagra cucullata* Auct.) in the following manner: "*Oriolus textor*, Ib. sp. 22 [Latham, Index Ornith., Vol. I, 1790, p.180] est du genre Tisserin (Textor)."

Since the present writer has already fully explained[1] the reasons for this change of generic name, it will be pertinent to quote the following statements there made:

"Messrs. Iredale and Bannerman have (Bull. Brit. Ornith. Club, XLI, May 26, 1921, pp. 128-129) incidentally cited from Lichtenstein a use of the generic name *Textor* prior to that of Temminck (Nouv. Rec. Planch. Col., II, livr. 54, February 12, 1825, p. [2] to texte of Genus *Oriolus* Linn. [in text]), and proposed to consider this *Textor* Lichtenstein (Verz. Doubl. Zool. Mus. Berlin, 1823, p. 24) ex Temminck a tentative synonym of *Malimbus* Vieillot. Unfortunately, however, *Textor* here is a nomen nudum. This prior publication of the generic name *Textor*, to which they refer, appeared in a note headed: '*Huic familiae adnumeramus species sequentes*, in museo nostra obvias.' The sixth (and last) paragraph of this note reads as follows: 'F. textrix n. Textor Malimbus Temm. *et Africae species complures. Vel ipsa F. Caffra,phalerata, Oryx,ignicolor,quoad rostri formam huc referendae.*' From this it is evident that 'Textor Malimbus Temm.' is not intended as a synonym or a substitute for 'F.textrix n.,' which precedes it, but merely as one of the species, of which *F. textrix* and

[1]Proc. Biol. Soc. Wash., Vol. XXXIV, June 30, 1921, p. 137.

'Africae species complures' are the others. This is still additionally evident from the second sentence of the paragraph of Lichtenstein's above quoted. Furthermore, the specific name *malimbus* apparently here for the first time appears in print, as we are unable to find that Temminck ever used it, and it is here, therefore a nomen nudum. This being the case, the generic name *Textor* used here in combination with it is likewise invalid from this introduction."

Since the generic name *Textor* Temminck is thus not preoccupied by *Textor* Lichtenstein, it should replace *Sitagra, as* already explained.

Hyphanturgus nigricollis melanoxanthus Cabanis

Hyphanturgus melanoxanthus CABANIS, Journ. f. Ornith., XXVI, No. 2, April, 1878, p. 205 ("Ost-Afrika" [type locality, Mombasa]).

A single adult male, taken at Lasamis on April 25, 1930, is in the collection. The plumage shows only slight evidences of molt.

Quelea quelea aethiopica (Sundevall)

Ploceus sanguinirostris var. *major (Pl[oceus]. aethiopicus)* SUNDEVALL, Ofv. k. Vet.-Akad. Förh. Stockholm, 1850, p. 126 (Sennar, Egyptian Sudan).

Seven specimens:

Adult male, Koroli, April 17, 1930. Length, 140 mm. "Iris brown; eyelids flame scarlet; bill garnet brown; legs and feet, orange cinnamon."

Adult female, Koroli, April 17, 1930. Length, 130 mm. "Eyelids isabella color; bill chamois; legs and feet, vinaceous fawn."

Adult female, Koroli, April 17, 1930. Length, 127 mm. "Bill apricot yellow; legs and feet, vinaceous cinnamon."

Three adult males, Koroli, April 17, 1930. Lengths, 131, 138, and 139 mm., respectively.

Adult female, Lasamis, April 21, 1930.

The last mentioned female is in process of molt.

Euplectes capensis kilimensis Neunzig

Euplectes capensis kilimensis NEUNZIG, Zool. Anz., Vol. LXXVIII, Nos. 5-8, September, 1928, p. 115 ("Moschi" [Tanganyika Territory]).

One adult male, Gunga Lake, May 20, 1930. Length, 160 mm.

This bird is in process of molt from the buffy dress into the black breeding plumage.

Euplectes diademata Fischer and Reichenow

Euplectes diadematus FISCHER and REICHENOW, Ornith. Centralbl., Vol. III, No. 11, June 1, 1878, p. 88 ("Malindi").

The collection contains a single adult male in fine breeding plumage, obtained at Kisima Kufuta on May 10, 1930. Length, 126 mm.

It is of interest in passing to note that of the species commonly referred to the genus *Euplectes*, one, *Euplectes taha*, differs structurally so much from the others that it should be removed to a genus of its own. From *Euplectes*, of which the type is *Loxia orix* Linnaeus, it is easily separable by its exceedingly short first (outermost) primary, which is only half as long as the primary coverts instead of nearly or quite as long as these. Furthermore, the feathers of the rump and upper tail coverts are very full and long, reaching to near the end of the tail, whereas in the other species the feathers of rump and upper tail coverts are normal and extend posteriorly over not more than three-quarters of the tail.

There is already a generic name available for *Euplectes taha* in *Taha* Reichenbach[1], of which the type is *Euplectes taha* Smith. The forms to be referred to this genus are:

Taha taha taha (Smith).

Taha taha ladoensis (Reichenow).

Taha taha stricta (Hartlaub).

Taha taha intercedens (Erlanger).

Coliuspasser eques (Hartlaub)

Vidua eques HARTLAUB, Proc. Zool. Soc. London, Vol. for 1863, No. 2, August 1, 1863, p. 106, pl. XV ("Kazeh, in eastern Africa" [=Tabora, Tanganyika Territory]).

One adult male, from Archer's Post, May 15, 1930. Length, 188 mm. "Iris dark brown; bill russian blue; legs and feet, black."

There seems to be little evidence that *Coliuspasser eques* is a subspecies of *Coliuspasser albonotatus*. Not the slightest indication of intergradation is discernible in any of the considerable series of both examined in the present connection. They are, therefore, apparently better considered distinct species.

Coliuspasser laticaudus suahelicus (Van Someren)

Penthetria laticauda suahelica VAN SOMEREN, Bull. Brit. Ornith. Club, Vol. XLI, May 26, 1921, p. 121 ("Nairobi River").

Five specimens, all from Gunga Lake:

Adult male, May 20, 1930. Length, 276 mm.

Adult male, May 22, 1930. Length, 275 mm. "Iris very dark brown."

Adult male, May 20, 1930. Length, 268 mm.

Immature male, May 24, 1930. Length, 218 mm. "Iris brown."

Adult female, May 23, 1930. Length, 141 mm.

The first mentioned specimen has still many buff edgings on the feathers of both upper and lower parts. The immature male is in brownish black plumage with a short tail.

Although the present subspecies is by some authors considered a form of *Coliuspasser ardens*, it seems to be specifically distinct.

[1]Singvögel, 1862, p. 73.

Both *Coliuspasser ardens ardens* and *Coliuspasser ardens teitensis* have no red on the head, and there seem to be no intermediates between them and *Coliuspasser laticaudus* which has the hind part of the crown, all the occiput, and the cervix red. Since in this respect *Coliuspasser laticaudus suahelicus* agrees with *C.l.laticaudus* it is thus properly considered a subspecies of this.

On the other hand *Coliuspasser ardens tropicus*[1] seems to be a recognizable race, differing from *Coliuspasser ardens ardens* in somewhat smaller size and broader tail feathers.

Uraeginthus cyanocephalus (Richmond)

Estrilda cyanocephala RICHMOND, The Auk, Vol. XIV, No. 2, April, 1897, p. 157 ("Useri River, near Mount Kilimanjaro").

One adult male, from Kinya, May 1, 1930. "Iris nopal red; bill light mallow purple, the tip darker; legs and feet, light russet vinaceous."

Steganura paradisaea (Linnaeus)

[*Emberiza*] *paradisaea* LINNAEUS, Syst. Nat., Ed. 10, Vol. I, January 1, 1758, p. 178 ("Africa" [=Angola]).

One adult male, from Balessa, March 30, 1930, collected by Windsor T. White. Length, 381 mm.

Family FRINGILLIDAE

Crithagra burtoni albifrons Sharpe

Crithagra albifrons SHARPE, The Ibis, Ser. 6, Vol. III, No. 9, January, 1891, p. 118 ("Kikuyu").

A single female was obtained at Gunga Lake on May 28, 1930. Length, 165 mm. "Iris dark brown; upper mandible fuscous, lower mandible drab gray; legs and feet, benzo brown."

There seem to be no trenchant and therefore satisfactory structural characters to separate *Loxia sulphurata* Linnaeus from *Poliospiza tristriata* (Rüppell) and the other species commonly associated with this in the genus *Poliospiza*, of which *Poliospiza tristriata* is the type. Although *Loxia sulphurata* is currently placed in the genus *Serinus* Koch, it should consequently be removed to the genus *Poliospiza*. Furthermore since *Loxia sulphurata* Linnaeus is the type of *Crithagra* Swainson[2] and since this name long antedates *Poliospiza* Bonaparte[3], it follows that the generic name *Crithagra* should supplant *Poliospiza* for the species now assembled thereunder.

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[1][*Coliuspasser ardens*] var. *tropica* Reichenow, Vögel Afrikas, Vol. III, 1st Hälfte, July, 1904, p. 135, in text ("Ost Afrika, von Sambesi nordwärts, und von Angola" [type from Karema, Tanganyika Territory]).

[2]Zool. Journ., Vol. III, No. 11, for December, 1827 (1828) p. 348.

[3]Consp. Gen. Avium, Vol. I, Part 2, 1850, p. 519.

Emberiza poliopleura (Salvadori)

Fringillaria poliopleura SALVADORI, Ann. Mus. Civ. Stor. Nat. Genova, Ser. 2, Vol. VI, May, 1888, p. 269 ("Sodde, Scioa").

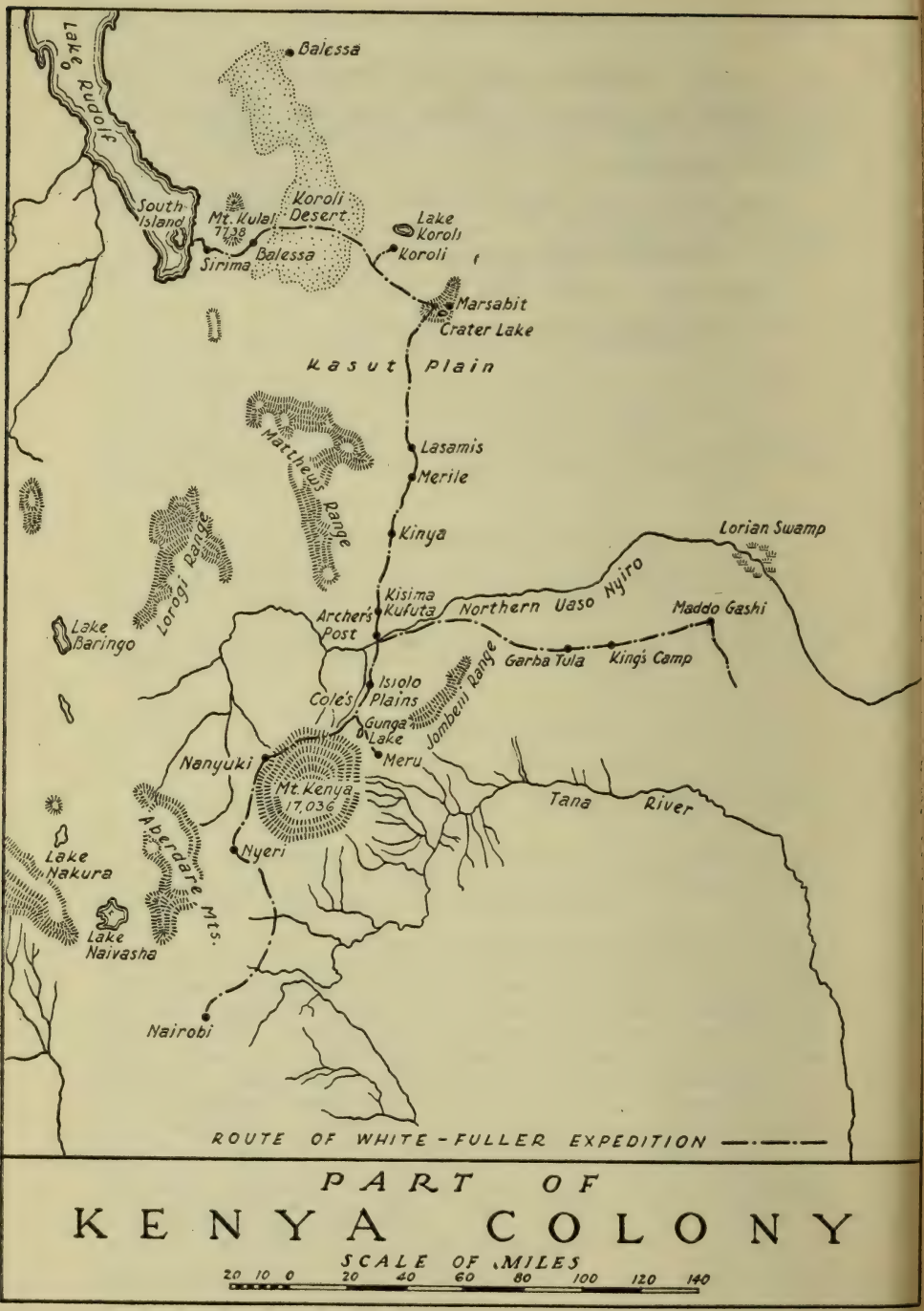
Three specimens:

Adult male, Koroli, March 26, 1930. Length, 150 mm. "Bill, legs, and feet, wood brown."

Juvenal male, Lasamis, April 22, 1930.

Juvenal male, Lasamis, April 23, 1930.

All 3 individuals are in process of molt.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Sirima
Balessa
Marsabit
Crater Lake
Kasut Plain
Matthews Range
Lasamis
Merile
Kinya
Lorian Swamp
Lorogi Range
Kisima
Kufuta
Northern Uaso Nyiro
Maddo Gashi
Lake Baringo
Archer's Post
Garba Tula
King's Camp
Isiolo
Cole's Plains
Gunga
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Jombeni Range
Nanyuki
Meru
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SCIENTIFIC PUBLICATIONS
OF THE
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A NEW RACE OF KANGAROO RAT FROM SOUTHWESTERN UTAH

BY

B. PATTERSON BOLE, JR.

In the course of the field work carried on by The Cleveland Museum of Natural History's Saline Valley Expedition of 1934 a small collection of mammals was obtained from points in southwestern and northeastern Utah. Examination of the material obtained revealed a new and previously unrecorded kangaroo rat of the *Dipodomys merriami* group, this group ranging widely in the states west and south of Utah.

Dipodomys merriami frenatus, subsp. nov.

UTAH BRIDLED KANGAROO RAT

Type.—From Toquerville, Washington County, Utah (Altitude 3200 ft.). Spec. No. 6771, adult, skin and skull, Cleveland Museum of Natural History; Collected by F. J. Tobin, May 14, 1934. Original Number: SVE-771.

Distribution.—Known only from the type locality, but presumably ranging widely in the deeper valleys and open deserts of southwestern Utah.

General Characters.—The darkest of the *merriami* group, easily distinguished from the other races by the darkened head and black, bold, complete arietiform marking.

Color.—The type, in worn winter pelage: Upperparts deep pinkish buff, heavily lined with blackish hairs on back and top of head, less so on sides and thighs, where the pinkish buff is clearest. Hip stripes, lateral tail stripes and postauricular spots clear white; a narrow white ring about the base of the tail. Feet (except for blackish plantar stripes) and underparts clear white to and including the sides of the nose. Dorsal and ventral tail-stripes dark brownish black; caudal tuft made up of sepia hairs, white basally. Arietiform marking black, pronounced, and continuous across top of nose. Color slightly washed out between eyes and whiskers; supraorbital spots indistinct and heavily suffused with the color of the top of the head. Ears small, white externally except for anterior fold; fold dusky medially and proximally, whitish along

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fold-over, with a spot of bright ochraceous-buff at the angle; inside of ears dusky. The ears do not fully cover the postauricular spots, which stand out conspicuously.

Skull.—Very similar to that of typical *merriami*, being somewhat smaller than the average of *merriami*, with somewhat less inflated bullae and consequently proportionately wider supraoccipital. These characters are not definite, however, as many examples of typical *merriami* at hand approach the present form in proportions and measurements.

Measurements.—The type, and one adult male topotype (in parentheses): Length, 207 mm. (232 mm.); tail, 113 (134); hind foot, 35 (37); skull: occipitonasal length, 33.5 (34.4); width across bullae, 21.9 (22.2); breadth across maxillary arches, 19.5 (18.7); width of maxillary arch (distal border of lachrymal), 5.2 (5.3); length of nasals, 12.7 (14.3); width of nasals (in front of incisors), 2.7 (3.2); least width, supraoccipital, 1.6 (2.2); maxillary toothrow (alveolar borders), 4.1 (4.1).

Remarks.—The present form needs comparison only with the animal described by Merriam as *Dipodomys merriami nevadensis*. Compared to *nevadensis*, *frenatus* is much darker and lacks the ochraceous cast of the Nevada animal. The black, complete facial marking of this race sets it apart strikingly and on the basis of this alone is easily distinguishable from *nevadensis*. *Frenatus* also differs in the much darker color of the upperparts, particularly of the head; in the smaller ear, darker tailstripes and less distinct supraorbital spot.

Specimens examined.—Two, the type and one topotype.
Of *Dipodomys merriami nevadensis* Merriam:

NEVADA: Pahrump Valley, 8*; Charleston Mts., 4*.
Of *Dipodomys merriami merriami* Mearns:

NEVADA: Fish Lake Valley, Esmeralda County, 3.

CALIFORNIA: Salt Camp, Saline Valley, Inyo Co., 23; North Sand Dunes, Saline Valley, Inyo Co., 78; Keeler, Owens Valley, Inyo Co., 1; Owenyo, Owens Valley, 1; Old Camp Independence, Inyo Co., 3; Division Creek Lava Flows, Owens Valley, Inyo Co., 1.

ARIZONA: Hardyville, Mohave Co., 1; White Tank Mts., Maricopa Co., 15; Perryville, Maricopa Co., 3; Wickenburg, Maricopa County, 1; Ashurst-Hayden Dam, Pinal Co., 4; Oracle, Pinal Co., 1.

NEW MEXICO: Steins Pass, Hidalgo Co., 1.

* *Courtesy of Dr. H. H. T. Jackson, U. S. Biological Survey*

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A NEW POCKET MOUSE FROM EASTERN CALIFORNIA

BY
B. P. BOLE, JR.

In the course of the Cleveland Museum of Natural History's Saline Valley Expedition of 1934 several pocket mice of a hitherto unrecognized race were collected. They may be known as:

Perognathus longimembris salinensis, subsp. nov.

SALINE VALLEY POCKET MOUSE

Type.—Spec. No. 6242, adult male, skin and skull, Cleveland Museum of Natural History; collected by P. N. Moulthrop, March 29, 1934. Original Number: SVE-242.

Type Locality.—1 Mi. N. of Salt Camp, elev. 1060 feet, on the west edge of the salt lake, Saline Valley, Inyo County, Calfiornia.

Distribution.—Mesquite thickets and woodlands on the floor of Saline Valley, chiefly west of the saltpans.

General Characters.—A well-marked race of *Perognathus longimembris* distinguished from others of the general region by its small size, pallid coloration and by numerous cranial characters.

Color.—Type, in winter pelage: Surface of upperparts pale ochraceous buff, lightly overlain with brownish and blackish; the hairs pale neutral gray at their bases on the rump, pallid neutral gray on the shoulders; top of head same color as back; sides same as back, except for a clear lateral line of pale ochraceous buff unmixed with darker colors; sides of face paler than the sides; underparts white to the roots of the hairs; tail pale ochraceous buff, slightly darkened above terminally; an indistinct tuft present; feet very pale, paler than back, sides or tail, almost white; ears slightly paler than back, but darkened about their edges.

Skull.—Very different from that of other races of the region, being much smaller in nearly every measurement, and very much smaller in certain ones, such as the length of the nasals, width of the rostrum at the anterior premaxillary borders as seen from above, interorbital width, maxillary toothrow, etc. The bullae project posteriorly farther beyond the occipital projection than in any other race the writer has seen.

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Measurements.—Type: Total length, 130 mm.; tail, 74; hindfoot, 17.5; occipito-nasal length, 19.5; basilar length, 13.9; mastoid breadth, 11.6; interparietal, 2.0x3.6; interorbital width, 4.9; nasals, 7.5; maxillary toothrow (alveolar borders), 3.1; greatest width of first left upper molar, 0.9; width of rostrum at anterior premaxillary borders, 2.1. For measurements of other specimens, see the following tables. There it will be seen that the interparietal of the type is the shortest of the series.

Remarks.—In order to determine satisfactorily the relationships of this *Perognathus*, it was necessary to measure series of specimens from several parts of Inyo County. The accompanying tables and charts indicate the results obtained. Before they can be appreciated to the fullest extent, a note on the distribution of *Perognathus longimembris* in the region in question is in order.

Saline Valley is an oval bowl some ten by twenty-eight miles in length. The floor of the valley lies at an elevation of one thousand feet above sea level, while the lowest point in the encircling mountain rim is a pass at slightly over 5000 feet in the Panamint Mountains, which separate Saline and Death Valleys. Another pass, at 5200 feet, leads northward over the Last Chance Range and the massif locally known as the "Middle Mountains" into the Eureka Valley. Southwards the only low egresses are a pair of passes, both over 6000 feet, in the "Hunter" Mountains that connect the Panamint and Inyo ranges. From Owens Valley on the west, Saline is separated by the stupendous scarp of the Inyo Mountains, which rise from 7000 to 10,000 feet above the valley floor.

Owens Valley is inhabited by the typical form of the *longimembris* group of pocket mice (see Grinnell, 1933, p. 147). This form ranges from the northern part of Owens Valley south along the eastern base of the Sierra Nevada, crossing the range at its southern extremities. It is fairly typical only on the *western* side of Owens Valley. The east side, in the vicinity of Keeler, is inhabited by an animal described by Elliot as *Perognathus pericalles* (1903, p. 252). This animal is synonymized under *P. longimembris longimembris* by Grinnell (loc. cit.). It is an exceedingly variable form, and is not very close to typical *longimembris* in the opinion of the writer, although the ultimate disposition of the name "*pericalles*" is not the concern of the present paper. Keeler, the type locality of "*pericalles*", is only seventeen miles from the type locality of *salinensis*, but within those seventeen miles every vegetational belt from desert scrub to cold subalpine pine forests is represented. The Inyo Mountains, on which this complex occurs, harbors no race of *longimembris* as yet discovered, except in its southeastern foothills. These rise from the Darwin Plateau, and there the form occurring is not *salinensis* and not *pericalles*, but *panamintinus*, a larger, heavy-bodied, dark-colored animal characteristic of the *Grayia* and tree yucca belts of the Panamint and Hunter Mountains and the Lee Flat—Darwin region.

A series of pocket mice from the Coso Hills several miles southeast of Keeler have the measurements of *panamintinus* and the color of typical *longimembris*. They are probably intermediate between these two races. They seem no closer to "*pericalles*" than to *panamintinus*, if as close. The "*pericalles*" series examined, one of the eight topotypical specimens kindly loaned by the Museum of Vertebrate Zoology, is unique among those series examined, in the great breadth of the skull in comparison to its length.

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Compared to typical *longimembris*, *salinensis* is so much smaller in all measurements except interparietal length that were it not for the existence of *panamintinus* the Saline Valley form might well be recognized as specifically distinct. The maximum measurements of a series of fourteen male *salinensis* lie in nearly all cases below the minima of a series of twelve male *longimembris* from Independence in Owens Valley. In color the two forms are not dissimilar, but the Saline animals are paler and lack the pinkish suffusion of the Owens Valley series.

Comparison with the "*pericalles*" series from Keeler is difficult because of the extraordinary variability of this stock. In the length of the nasals, which are short, the Keeler animals approach the *salinensis* series. This is also the case with the occipitonasal and basilar lengths of the skull, but in the case of the mastoid breadth they are the farthest from *salinensis*. Thus the skull of *salinensis* is, at a glance, much slenderer, especially across the braincase; the tympanic bullae are more inflated, projecting much farther behind the occiput; the rostrum is very much slenderer, although of about the same length; and the teeth are smaller individually and in series. Externally, the hindfoot of *salinensis* is diminutive in comparison to "*pericalles*" and the pale ochraceous of the upper parts is paler in fresh pelages than in that stock.

Compared to series of *panamintinus* from Lee Flat and the Jackass Springs region, *salinensis* differs so amazingly in color that it is separable on this basis alone. In nearly all the cranial measurements taken, the *salinensis* averages are well below those of the mountain form, although the maxima of the one series overlap the minima of the other broadly. The proportions of the skulls of the two series are similar however, except in the slenderer rostrum of the lowland form and its much weaker dentition. The relationship of *salinensis* to *panamintinus* is definitely closer than to any other form of the immediate region, as might be expected on geographical grounds, since *panamintinus* is the Saline animals' nearest neighbor—much, much nearer, ecologically, than "*pericalles*". In this connection it is interesting that the small series from Jackass Springs (Grapevine Canyon) in the Panamint Mountains is somewhat paler on the average than specimens from Lee Flat or from the Panamint Mountains farther to the southeast, and indicate a slight tendency towards *salinensis*, although their measurements fail to corroborate this. Intergradation between the two forms, if it occurs at all, presumably occurs at the extreme south end of Saline Valley and in the lower reaches of Grapevine Canyon.

Cranially, *salinensis* is closer to *bangsi* of the Colorado desert than to any of the nearer forms. Most of the cranial measurements of the type of *bangsi* are almost exactly the average measurements of the *salinensis* series. But in toothrow, width of the first upper molar, and the width of the rostrum, the Saline Valley form is easily separable, being smaller in each case, while its external measurements are much smaller than in any specimen of *bangsi* examined by me. The small hind foot of the northern animal is again definitive.

In summary, it appears that at some time in the past a stock of pocket mice of the *longimembris* group became established on the floor of Saline Valley, where dense thickets of mesquite and screw-bean afforded it suitable cover and food supply. Presumably this stock originated from colonies of *panamintinus* inhabiting the higher

elevations of the valley walls to the south and east, but may have come from *bangsi* which most clearly resembles the present day race inhabiting the valley. It is most unlikely that the ancestors of *salinensis* came over the Inyos from Owens Valley, since those high mountains are inhabited by a very different fauna characterized by *Callospermophilus*, the mountain bluebird, the Clarke crow, and other species of subalpine affinities. *Perognathus* does not occur there above 7000 feet, and *Perognathus longimembris* does not occur at all so far as is known. It is equally unlikely that the ancestors of *salinensis* came from the north, since the source of supply would probably then have been the dark race *nevadensis* which is not known to occur south of Oasis, in Mono County. The so-called "Middle" Mountain mass lying between Oasis and Saline Valley is apparently uninhabited by any race of *longimembris*.

Specimens examined.—

Perognathus longimembris longimembris:

San Diego County: La Puerta Valley, 1[1]

Los Angeles County: Lancaster, 1[1]

Inyo County: West Side of Owens Lake, 6[2]; Grays Meadow, 1; Independence, 18; Lower Centennial Springs, Coso Hills (not typical), 12; Lone Pine Creek, 23.

Perognathus longimembris panamintinus:

Inyo County: Lee Flat, 16; Grapevine Canyon, 1 mi. W. of Jackass Springs, Panamint Mountains, 4; Willow Spring, 1[1]; "Panamint Mts.", (presumably Tucki Mt. region), 1[1]; Townes Pass, 1; Perognathus Flat, 8 (Topotypes).

Perognathus longimembris bangsi:

Yuma County (Ariz.): Parker, 1[1].

Riverside County: Whitewater, 1[1]; Palm Springs, 2[1] (type and topotype).

Perognathus longimembris salinensis:

Inyo County: Salt Camp, Saline Valley, 21; North Sand Dunes, Saline Valley, 1.

Perognathus pericalles Elliot:

Inyo County: Keeler, 8 (topotypes)[3]; 2 Mi. S. E. of Keeler, 1.

[1] Museum of Comparative Zoölogy, [2] U. S. Biological Survey Coll., [3] Museum of Vertebrate Zoology.

REFERENCES

Elliot, D. G. 1903, Dec. Description of twenty-seven apparently new Species and Subspecies of Mammals. Field Columbian Museum Publication No. 87. Zoöl. Ser., Vol. III, No. 14.

Grinnell, J. 1933, Sept. 26. Review of the Recent Mammal Fauna of California. Univ. Calif. Publ. Zoöl. Vol. 40, No. 2, pp. 71-234.

Spec. No.	Total Length	Tail	Hindfoot	Occipito-nasal Length	Basilar Length (Henselian)	Mastoid Breadth	Interparietal Length x Breadth	Interorbital Width	Nasals	Maxillary Toothrow	Greatest Width of M^1	Width Nasals at Premaxillary borders
6607♂	142	85	20	22.3	15.4	12.0	2.4x4.0	5.7	8.8	3.5	1.1	2.3
6609♂	145	81	20	22.1	15.5	12.3	2.5x4.5	5.3	9.0	3.5	1.1	2.2
6610♂	148	84	20	22.9	16.0	12.3	2.7x4.4	5.5	9.1	3.5	1.1	2.3
6611♂	145	81	19.5	22.6	15.5	12.6	2.6x4.2	5.8	9.0	3.3	1.0	2.5
6612♂	150	82	20						8.5	3.5	1.0	2.4
6613♂	147	84	20		15.5	12.2	2.6x4.4	5.6	9.1	3.5	1.0	2.1
6614♂	139	78	19.5					5.7	9.0	3.5	1.1	2.4
6618♂	147	83	20	22.5	15.5	12.4	2.5x4.0	5.9	9.1	3.6	1.1	2.4
6619♂			20	22.4	15.2	12.2		5.3	9.0	3.6	1.0	2.4
6620♂	150	83	20	23.1	15.7	12.6	2.5x4.1	5.3	9.5	3.6	1.2	2.3
6621♂	145	79	19.5	22.7		12.4	2.7x4.6	5.7	9.1	3.5	1.1	2.5
6608♂	143	80	19.5									
Averages	145.54	81.81	19.83	22.57	15.54	12.33	2.54x4.27	5.58	9.02	3.51	1.07	2.35
6615♀	146	83	19.5	22.4	15.5	12.5	2.5x4.0	5.3	9.0	3.5	1.2	2.3
6622♀	145	78	19.5	22.3		12.1	4.1	5.4	9.0	3.6	1.1	2.3
6623♀	139	81	19.5	22.3	15.4	12.3	2.9x4.3	5.5	8.9	3.5	1.0	2.4
6624♀	143	81	19.5				2.5x4.6	5.6	9.0	3.7	1.2	2.3
6717♀	142	73	19	22.2	15.1	11.8	2.6x4.2	5.3	9.2	3.5	1.0	2.3
Averages	143	79.2	19.4	22.3	15.33	12.17	2.62x4.24	5.43	9.02	3.56	1.10	2.32

TABLE I. Measurements of a series of *Perognathus longimembris longimembris*, all from Independence, Inyo County, California, elevation, 3800 feet, except number 6717, which was taken at Grays Meadow, five miles southwest, at an elevation of 5600 feet.

Spec. No.	Total Length	Tail	Hindfoot	Occipito-nasal Length	Basilar Length	Mastoid Breadth	Interparietal Length x Breadth	Interorbital Width	Nasals	Maxillary Toothrow	Greatest Width of M^1	Width of Rostrum at Anterior Dorsal border of Premaxillae
6659♂	133	70	20	21.8	15.0	12.2	3.0x4.0	5.7	8.4	3.5	1.0	2.3
6660♂	138	70	20	21.9	14.9	12.1	2.6x3.8	5.4	8.3	3.4	1.1	2.3
6661♂	147	77.5	19.5	21.7		12.1	2.7x4.3	5.5	8.5	3.4	1.0	2.1
6662♂	128.5	68	19	21.4	14.9	12.2	2.9x3.8	5.4	8.1	3.4	1.0	2.2
Averages	136.62	71.37	19.62	21.7	14.93	12.15	2.8x3.97	5.5	8.32	3.42	1.03	2.23
6652♀	136	70	19	21.3	14.6	12.2	2.6x3.6	5.2	8.1	3.4	1.2	2.3
6653♀	135	71	20	21.8	15.0	12.3	2.6x3.7	5.5	8.2	3.4	1.1	2.3
6654♀	120	68	19.5	21.2	14.7	11.9	2.8x3.6	5.2	8.2	3.5	1.0	2.0
6655♀			19.5	21.7	15.1	12.4	2.2x3.9	5.5	8.8	3.4	1.2	2.3
6656♀	138	70	19	22.1	15.0	12.2	2.5x3.4	5.0	8.5	3.5	1.2	2.2
6657♀	131	72	18				2.7x4.0	5.0	8.2	3.3	1.0	2.2
6658♀	128.5	70	18	20.8	14.5	12.1	2.4x3.9	5.3	8.0	3.2	1.1	2.0
6663♀			19.5	22.0	15.0	12.3	3.0x4.3	5.3	8.6	3.4	1.1	2.3
Averages	131.41	70.16	19.06	21.55	14.84	12.2	2.6x3.8	5.25	8.32	3.38	1.11	2.2

TABLE II. Measurements of *Perognathus longimembris* from the Lower Centennial Springs, Northeast base of the Coso Hills, Inyo County, elevation, 5200 feet. These specimens are closest to *panamintinus* in measurements and to typical *longimembris* in color.

Spec. No.	Total Length	Tail	Hindfoot	Occipito-nasal Length	Basilar Length	Mastoid Breadth	Interparietal Length x Breadth	Interorbital Width	Nasals	Maxillary Toothrow	Greatest Width of M^1	Width of Rostrum at Anterior Dorsal border of Premaxillae
						(*a*) *Males*						
6715♂	133	70	20	21.0	14.5	12.3	3.0x4.5	5.2	8.1	3.5	1.0	2.4
6716♂	136	75	20	21.7	14.9	12.5	2.6x3.8	5.2	8.6	3.3	1.0	2.5
6718♂	138	77	19.5	21.0	14.4	11.8	2.8x4.0	5.2	8.2	3.2	1.0	2.4
6719♂	145	80	19	21.7	15.1	13.0	2.7x4.0	5.6	8.0	3.3	1.1	2.3
6721♂	135	72	19	22.2	15.4	12.6	2.6x4.0	5.5	8.5	3.3	1.0	2.2
6722♂	140	75	19	22.0	15.2	12.4	2.7x4.4	5.7	8.6	3.5	1.0	2.1
6741♂	135	75	20			12.1	2.9x4.3	5.3	8.1	3.4	1.0	2.4
6742♂			20			12.2	2.7x3.8			3.4	1.0	2.2
6745♂	138	74	20	22.0	14.8	12.0	2.7x3.5	5.2	8.5	3.5	1.0	2.1
6746♂	138	74	18		15.0	12.1	2.6x3.4	5.2		3.2	0.9	2.3
6748♂			18.5	22.0	14.9	12.3	2.5x3.7	5.3	8.4	3.3	0.9	2.2
Averages	137.55	74.67	19.36	21.74	14.91	12.3	2.71x3.94	5.34	8.33	3.35	0.99	2.28
						(*b*) *Females*						
6720♀	135	70	20	21.8	14.6	12.7	2.5x3.8	5.2	8.2	3.3	1.2	2.3
6723♀	137	72	18.5	22.4	14.7	12.2	2.9x4.0	5.3	8.5	3.5	1.2	2.3
6743♀	142	76	20	22.1	15.4	12.4	2.5x3.6	5.3	8.5	3.5	1.1	2.2
6744♀	130	64	17.5	21.0	14.6	12.2	2.5x3.6	5.7	8.2	3.3	1.0	2.1
6747♀	138	72	18	21.7	15.0	11.9	2.5x3.5	5.2	8.4	3.4	1.0	2.3
Averages	136.4	70.8	18.8	21.8	14.86	12.28	2.58x3.7	5.34	8.36	3.4	1.1	2.24
						(*c*) *Grapevine Canyon*						
6684♂	125	65	18	20.3	13.5	11.6	2.6x4.0	5.3	7.9	3.0	0.9	2.3
6682♀	134	72	19.5					5.4	8.4	3.3	1.0	2.3
6683♀	133	74	18.5		14.4	11.8	2.9x3.5	5.2		3.3	0.9	
6685♀	137	70	19.5	21.4	15.5	11.8	2.5x3.5	5.3	8.4	3.5	1.0	2.2
Female Averages	134.67	72	19.17	21.4	15.0	11.8	2.7x3.5	5.3	8.4	3.37	0.97	2.25

TABLE III. Measurements of *Perognathus longimembris panamintinus* males (a) and females (b) from Lee Flat, fifteen miles north of Darwin, Inyo County; elev. 5200 ft. and (c) of four specimens from Grapevine Canyon, 1 mi. west of Jackass Spring, Inyo County, elev. 5300 feet. Specimen number 6684 is subadult.

Spec. No.	Total Length	Tail	Hindfoot	Occipito-nasal Length	Basilar Length (Henselian)	Mastoid Breadth	Interparietal Length x Breadth	Interorbital Width	Nasals	Maxillary Toothrow (Alveolar borders)	Greatest Width of M^1	Width of Rostrum at Anterior border of Premaxillae
6292♂	137	76	17.5			12.3	2.3x4.0			3.1	0.9	
6320♂			18.0	20.5	14.3	11.8	2.5x3.9	5.1	7.8	3.1	1.8	1.8
6335♂			18.0	20.5	14.0	11.7	3.0x3.9	4.9	8.0	3.0	0.9	1.9
6343♂	130	75	18.5						7.3		0.9	
6332♂	132	83	19.0	20.7	13.8	12.0	2.5x3.6	5.1	7.9	3.1	1.0	2.0
6341♂	128	69	16.0	19.5	13.4	11.7	2.6x3.7	4.9	7.6	3.0	0.9	2.0
6348♂	129	69	18.0				2.5x3.5	4.9		3.1	0.9	
6336♂	137	81	17.0					5.2	7.8	3.0	0.9	2.0
6340♂			19.0			10.9	2.5x3.6			3.1	1.0	
6242♂	130	74	17.5	19.5	13.9	11.6	2.0x3.6	4.9	7.5	3.1	0.9	2.1
6281♂	131	69	19.0	20.3	14.0	12.0	2.4x4.1	4.9	8.0	3.1	1.0	1.8
6346♂	127	73	17.5	19.9	13.9	11.8	2.5x3.8	5.0	7.5	3.0	0.8	2.0
6342♂	138	79	19.0	19.2	13.8	11.6	2.5x4.1	4.8	7.6	3.1	1.0	2.0
6349♂			17.5									
Averages	131.9	74.8	17.96	19.95	13.88	11.72	2.48x3.8	4.97	7.77	3.06	0.91	1.95
6345♀	134	80	20.0	20.4	14.5	11.9	3.0x3.4		7.6	3.0	0.8	2.0
6498♀	133	74	19.0	20.8	13.9	11.5	2.7x3.3	4.8	8.0	3.0	0.9	2.1
6307♀	132	67	18.0	20.3	14.1	11.7	2.9x3.7	4.9	8.2	2.9	0.9	2.1
6327♀	134	70	17.0	19.7	13.8	11.5	2.7x4.0	5.1	7.6	3.0	0.8	1.8
6321♀	129	73	19.0	20.6	14.0	11.4	2.4x3.5	5.0	7.7	3.1	1.0	2.0
6347♀	133	70	17.0								0.9	
Averages	132.5	72.33	18.33	20.36	14.06	11.6	2.74x3.56	4.95	7.82	3.00	0.88	2.0

TABLE IV. Measurements of *Perognathus longimembris salinensis* all from Salt Camp, Saline Valley, elev. 1100 feet, except No. 6498, which was taken at the North Sand Dunes, elev. 1200 feet.

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SCIENTIFIC PUBLICATIONS
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VOL. V ISSUED, DECEMBER 4, 1937 No. 3

AN INSULAR FORM OF WHITE FOOTED MOUSE FROM ANTICOSTI ISLAND

BY
PHILIP N. MOULTHROP

A series of white footed mice of the *Peromyscus maniculatus* group was collected by the Braund-McCullagh Expedition to Anticosti Island in June and July, 1937, for this institution. This series proves upon examination to be distinct from the form on the mainland and from any of the other forms in eastern North America.

Peromyscus maniculatus anticostiensis, subsp. nov.

ANTICOSTI ISLAND WHITE FOOTED MOUSE

Type.—From Fox Bay, at the eastern end of Anticosti Island, Province of Quebec. Spec. No. 12128, adult, skin and skull, Cleveland Museum of Natural History; collected by Philip N. Moulthrop, June 22, 1937. Original Number AI.-28.

Distribution.—Known only from the type locality but undoubtedly ranging over all of Anticosti since the Fox Bay region is typical of the entire island.

General Characters.—Very dark, with darker and more pronounced dorsal stripe than in any of the eastern members of the *maniculatus* group.

Color.—The type, in unworn pelage: Sides and lateral upper parts hair brown* to dark grayish brown tinged with ochraceous-tawny, the latter color being most noticeable at the dividing line between white under parts and dark upper parts; median dorsal region mummy brown to blackish brown, beginning in the center of the forehead and widening to include the region between the ears, thence extending down the back in a wide band, diminishing in width slightly to the base of the tail. Base of whiskers and orbital region black. A light grayish patch extends from tip of nose to midway between the eyes and is in sharp contrast with darker forehead and orbital region, a sparse sprinkling of white hairs heightening this effect; cheeks ochraceous-

**Color terms used are from Ridgeway's Color Standards.*

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tawny. Ears blackish brown narrowly edged with whitish. Under parts white; feet white; upper fore-arm dusky, blending into color of sides; ankles dusky; thighs same color as dorsal stripe. Tail bicolor; white below, fuscous above, liberally sprinkled with white hairs. Young, in juvenile pelage: General color slate gray overlaid with white on under parts and blending into wide dorsal band of blackish mouse gray.

Skull.—A series of skulls from Anticosti Island is readily distinguishable from other eastern forms of *maniculatus*, but in some respects approaches *eremus*. There is a pronounced tendency for the anterior border of the interpterygoid fossa to be inverted rather than U or V shaped. In *eremus* this character is much weaker, and only slightly noticeable in *argentatus*, but in the present form the process forming the point of the inverted border of the interpterygoid fossa is heavy enough to form a slight ridge running half-way down the palatine shelf. The interpterygoid fossa is wider and less constricted medially than in typical *maniculatus*. The diastema and rostrum are much longer than in *gracilis* or *abietorum*, and slightly longer than in *maniculatus* and *eremus*. The zygomata are broad and spreading; the braincase is proportionally broad. The zygomatic breadth is greater and interorbital constriction narrower than in any of the eastern members of the group; postorbital region heavier and broader and zygomatic arches heavier and stronger than in other eastern forms; nasals short; shelf of bony palate comparatively long. The Anticosti form is distinguishable from *gracilis* by the greater distance between the palatine foramina and the plane of the anterior surface of the first molars. Foramen magnum small; incisors comparatively weak and slender. In a series of twelve adult skulls the maxillary tooth row (from alveolar borders) was 3.5 mm. in each individual. No other series examined showed any such uniformity; *maniculatus* and *eremus* both averaging 3.7 mm.

Measurements.—Average of 12 adults from Fox Bay (type in parentheses):Length, 186.2 mm. (182 mm); tail, 92.5 (91); hindfoot, 21.5 (21); ear from base, 16.6 (17); skull: greatest length, 25.8 (25.1); basilar length, 19.8 (19.2); zygomatic breadth, 13.0 (12.9); inter-orbital constriction, 3.7 (3.7); nasals, 10.0 (9.9); shelf of bony palate, 4.5 (4.6); palatine slits, 4.9 (4.9); diastema, 7.4 (7.3); rostrum (from notch), 9.1 (8.9); maxillary toothrow (alveolar borders), 3.5 (3.5).

Remarks.—The Anticosti form tends toward *gracilis* and *abietorum* in the color of the pelage, and toward *eremus*, the Magdalen Island form, cranially. However, *gracilis* and *abietorum* are not as dark, nor is the dorsal stripe as pronounced in the latter forms. *Eremus* may be separated instantly on the basis of its much larger foramen magnum. The series of twelve adults examined was remarkably uniform, likewise a series of ten young in juvenile pelage showed practically no variation.

Specimens examined.—

Peromyscus maniculatus anticostiensis, subsp. nov.

Quebec: Fox Bay, Anticosti Island, 22 (including 10 young).

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Peromyscus maniculatus maniculatus (Wagner).

NORTHWEST TERRITORY: Oxford House, 2*; Echamamish River, 2*.

HUDSON BAY: York Factory, 2*.

Peromyscus maniculatus eremus Osgood.

QUEBEC: Magdalen Islands, 6*.

Peromyscus maniculatus gracilis (Leconte).

QUEBEC: Bark Lake, 2.

ONTARIO: Haliburton, 2.

Peromyscus maniculatus abietorum (Bangs).

MAINE: Vinalhaven 5; Matinicus Island, 9.

Peromyscus maniculatus argentatus (Copeland and Church).

NEW BRUNSWICK: Grand Manan Island, 20.

**Courtesy of Dr. H. H. T. Jackson, U. S. Biological Survey.*

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THE QUADRAT METHOD OF STUDYING SMALL MAMMAL POPULATIONS

By
B. P. Bole, Jr.

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1939

(Some of this work was submitted in partial fulfillment of the requirements for the degree of Master of Arts at the Graduate School of Western Reserve University)

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TABLE OF CONTENTS

Page

List of Tables and Figures 18

Introduction 19

Literature 20

Quadrat Work of Investigators from The Cleveland Museum 23

Field Methods 25

Comparison of the Yields of Different Sizes and Types of Quadrats

1. The Yields of 10-Meter and 150-Foot Quadrats Compared 26
2. The 50-Foot and 10-Meter Quadrats Compared 35
3. The 50-Foot and 150-Foot Quadrats Compared 35
4. Experiments with 50-Foot Quadrats Insulated with Sheet-Iron 44
5. The 100-Foot Quadrat, 0.229 Acre 48
6. Circular Units: Their Advantages and Disadvantages . . . 50

Discussion

1. Raunkaier's Law of Frequence 51
2. General Considerations (Drift Rates, Baiting, etc.) 51

Populations (Annotated List with Preliminary Discussion) 64

Conclusions 74

List of References 75

LIST OF TABLES AND FIGURES

Page

TABLE I. Summary of the Total Yields from 10-Meter Quadrats, North Chagrin Metropolitan Park, Cuyahoga County, Ohio....27

TABLE II. Populations-per-acre based on Total Yields from Five 10-Meter Quadrats and the 3-Day Yields from 150-Foot Quadrats in Beech-Maple Forest at North Chagrin Park....30

TABLE III. 1935 3-Day and Total Yields from the Five 10-Meter Quadrats at North Chagrin Park....31

TABLE IV. 1935 Record of the 150-foot Quadrat at North Chagrin Park....32

TABLE V. Comparison of Population Estimates based on Yields of the North Chagrin 10-Meter and 150-Foot Quadrats in August, 1935....33

TABLE VI. Population Estimates based on the Yields of Fourteen 150-Foot Grids (each of nine 50-Foot Units), and on the Yields of the Central Quadrats of these Grids....34

TABLE VII. Summary of Quadrat-Trapping Work on Little Mountain, Geauga County, Ohio, in 1933....39

TABLE VIII. The Yields of Three 150-Foot Quadrats on Little Mountain for the Years 1933 and 1935....40

TABLE IX. Populations-per-acre in Different Forest Communities on Little Mountain. Figures Based on the 3-Day Yields of 150-Foot Grids and their Central 50-Foot Quadrats....41-42

TABLE X. Checklist of the Mammals Mentioned in This Report....43

TABLE XI. Yields of Control and Insulated Quadrats (50-Foot Size) Compared....47

TABLE XII. Climax Forest Percentages of Frequence of Small Mammals in the Cleveland, Ohio Region, 1935-39, and their Distribution into Groups According to Raunkaier's Law....53

TABLE XIII. Drift Rates of 10-Meter and 150-Foot Quadrats Compared to Each Other and to Certain Basic Quadrat Relationships....55

TABLE XIV. Small Mammal Populations in the Cleveland Region, 1935-39....72-73

FIGURE 1. Population-estimate-per-acre plotted Against Quadrat Size, the Yield considered Constant....54

FIGURE 2. Average Daily Yields of Small Mammals from Four Different Sizes of Quadrats Operated 1932-39 Inclusive....58

FIGURE 3. Average Daily Yields from 150-Foot Quadrats for each of Six Different Years....59

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INTRODUCTION

In 1932 The Cleveland Museum of Natural History began a series of intensive ecological studies of different habitats in the Cleveland region. In each of these, the problem of small mammal abundances immediately presented itself. Williams (1936) and Aldrich (MS.) attacked the problem by using trapping quadrats of small size. In the following year, 1933, the writer and his co-worker, Mr. P. N. Moulthrop, took over the quadrat trapping portions of their investigations and started a comparative study of the yields and value of different sizes of quadrats. The study has been carried on exhaustively since that time. Conclusions have been carefully checked through several years of experience and the results are now ready for publication.

The writer is deeply indebted to Dr. S. Charles Kendeigh, of the University of Illinois, for his guidance and advice during the course of this work, which was partially completed while Dr. Kendeigh was a member of the faculty of Western Reserve University; and to Drs. Arthur B. Williams and John W. Aldrich, of The Cleveland Museum of Natural History, for their advice and generous permission to incorporate some of their data in the present paper; and lastly, to the unflagging interest and zeal of the writer's co-worker, Mr. Philip N. Moulthrop, and his several field assistants, especially Mr. Scott R. Inkley and Mr. Winston Jesseman. This paper would have taken many more years to attain even its present preliminary status had it not been for their co-operation and industry in the field. Further acknowledgments are certainly due the host of property owners who have permitted repeated invasions of their lands by field workers from The Cleveland Museum of Natural History. In this connection, our especial thanks go to the Cleveland Metropolitan Park Board, to the Little Mountain Club, to the Baldwin Bird Research Laboratory, and to Messrs. Woods and Charles King, Trustees of the Cleveland Museum.

LITERATURE

The need for some method of estimating mammal populations has long been recognized. Various workers have in recent years emphasized the lack of standardized quantitative methods; others have gone farther and have suggested different ways in which counts may be made. The first concrete suggestion for a basic unit for population estimates was that of Grinnell (1914, p. 92) who advocated the use of "trap-nights". The total number of traps set in each locality is multiplied by the number of nights the trapline functions. The yield for each species per trap-night is then figured out, or the yield for all trap-nights. This method is admirably adapted to the needs of the field collector of small mammals. It has been frequently followed by various writers in subsequent years in determining the relative abundance of species in given districts; but there are several difficulties connected with its use, as suggested by Dice (1931, p. 377), to wit: the skill of the individuals setting the traps varies considerably; the yield decreases after the first night in most cases; the weather, make of traps, age of traps, and the species of animal, all afford factors tending to affect the significance of the total yields. Another difficulty might be noted from the ecologist's point of view: trap-nights give no indication of the actual abundance in numbers per unit area unless combined with other methods. Dice (loc. cit.) himself used "first trap-nights" only in some of his work, but concludes that, owing to the fact that certain species come to traps earlier and more readily than others, they do not give fair estimate of the relative abundance of the various species in the area trapped.

Besides using trap-nights per unit area, Taylor (1930, pp. 523-542) made counts of different species along lines of specified lengths and also made counts of the animals killed around standard amounts of poisoned grain. In addition, he used quadrats in making counts of hares and rabbits. These quadrats were designed to prevent ingress and egress of only the larger rodents. He also counted fecal pellets in given areas, and the numbers of used burrows and runways, a method also advocated by Phillips (1931, pp. 633-649), who suggested the basing of population estimates on the average number of

animals in certain sample lairs or burrows, the average number per sample lair being multiplied by the total number of lairs per unit area. Recently MacLulich (1937, pp. 25-39) has shown that counts of droppings in a series of small quadrats can give a reliable index of the relative abundance of certain species. Grinnell and Storer (1924, p. 22), suggested using time units in place of space units, the species or individuals captured or seen per day or hour being substituted for areal units. The writer has found this useful in obtaining figures on the abundance of diurnal species, but the method is obviously under limitations when used at night, and is subject to the full brunt of varying conditions and possible interpretations, due to the weather and other factors above mentioned. Dice (1931) suggested that the use of indices affords the best method of expressing the relative abundance of species. He would list the number of individuals of each species observed or taken in each ecological habitat, and would base his indices on the frequency of each species in any one habitat. He stresses that the indices must be specific for each habitat and that the different techniques necessary for the capture of different size-groups of mammals must be taken into account. Subsequently, he has abandoned the use of indices in favor of population estimates based on the computation of home-ranges from the data yielded by large-size quadrats (1938, pp. 119-130). Hamilton (1937, p. 780) secured figures on the populations of *Microtus pennsylvanicus* about Ithaca, New York, by trapping all the mice out of areas "more or less defined by natural boundaries", varying from one-half to twelve acres.

Quadrats have long been used as a means of determining the abundance of plants in ecological studies. For an account of the development of the quadrat method, the reader is referred to Kenoyer (1927). Thus Pound and Clements (1898) developed a scale of seven degrees of frequence, based on quadrats five meters on a side. Jaccard (1912) used adjacent quadrats as bases for a frequence index. Using much of the early work in addition to his own, which involved the use of circular units instead of quadrats, Raunkaier (1918) developed his "Law of Frequence". Briefly, this is explicable as follows: Given a number of quadrats, perhaps ten; and a number of species, ten for instance; if one species occurs on all ten quadrats, its *percentage of frequence* is 100; if on but one, 10. There will be a higher number of

species occupying a small proportion of the quadrats than of species occupying most or all of them. The ratio of these frequences will be 5:2:1:0:1, where each number refers to the frequency for each of five classes of abundance (classes A, B, C, D, E, referring to the occurrences of a single species in 1-20, 21-40, 41-60, 61-80, 81-100 per cent of the quadrats, respectively). As Kenoyer (1927, p. 343) points out, this may be expressed by a graph, wherein the curve representing the numbers of frequences has two crests, one much lower than the other. The first crest represents the number of least frequences and the second the number of the greatest. Raunkaier himself based this concept on over 8000 percentages of frequence, which arranged themselves according to the above formula. Kenoyer found that his surveys of vegetation in the Lake Michigan region supported the Raunkaier formula. From the point of view of the developmental history of the subject of this paper, it is of importance that he (1927, p. 236) suggested the use of this formula and, by inference, the quadrat method, with regard to birds and mammals. He found that the formula held very well for sweeps of the insect-net over known grass-land areas, and for micro-organisms in hay infusions. The applicability of the formula to small mammals will be discussed shortly.

A number of other workers, in addition to Taylor (loc. cit.), have used quadrats in studying small mammal populations, among them Elton, Middleton and their co-workers (several papers), Townsend (1935), Chitty (1937), Williams (1936), and Hatfield (1938). Townsend's paper appeared after the initiation of this work. In it is presented a somewhat novel method of obtaining actual figures for small mammals per acre of ground. The method devised was that of the "moving quadrat" that consisted of three parallel trap-lines one rod apart. Each trap-line consisted of a row of triads of traps three feet apart. Thus the trap-lines were in all 33 feet long and about of the same depth, forming a quadrat of a size intermediate between the 10-meter and 50-foot sizes, later to be considered in this report, but much nearer the 10-meter unit. The trap-lines were "cascaded" by shifting the rearmost row to a new position one rod in front of the first row. This was done every day for fourteen days, during which time a stationary trap-line was run in the same habitat. The idea was evidently suggested by the work

of Elton (1925). Populations per acre were estimated on the basis of the yield over a three-day period.

Chitty (1937) used blocks of traps (Tring live traps) spaced so as to form a quadrat 90 feet on a side. He concluded that there was a large amount of drift into units of this size from adjacent terrain, and later used areas "9 or 10 times as large", concluding that even these larger units are subject to considerable drift. Hatfield (1938) used small quadrats (24 feet on a side) in studying the habitat preferences of certain small mammal species in Minnesota. Williams (1936) made estimates of population per acre on the basis of the yields during several days from quadrats 10 meters on a side. It was his four-year study of the North Chagrin forest near Cleveland that stimulated the present investigation. His original population studies were made with but one size of quadrat. As the writer took over the quadrat portion of Dr. Williams' researches in 1933, all of the quadrat trapping data secured by workers from the Cleveland Museum is incorporated in this paper, including that which has already been published by Williams (1936).

Dice (1938, pp. 119-130) used quadrats in the course of studying small mammal home-ranges. His quadrats were of single chains on a side (1 chain = 66 feet) and of multiples thereof. From the data obtained through the use of live traps and the marking of his animals, he was able to derive an interesting formula for the rough calculation of an individual home range: $NX^2 = (A + X)(B + X)$, where N is the number of adults of the sex or age group being considered, known to be living on the quadrat, X the mean width of an individual home range, A the width of the quadrat from outside trap to outside trap, and B the length of the quadrat. The difficulty arising from this method is that the quadrat must approximate the actual home range or the results are subject to considerable error.

QUADRAT WORK OF INVESTIGATORS FROM THE CLEVELAND MUSEUM

Dr. Williams (loc. cit.) was primarily interested in the ecology of sixty-five acres of virgin beech-maple forest situated in the northeastern corner of Cuyahoga County, Ohio at the North Chagrin Reservation of the Metropolitan Park System of Cleveland. His

trapping of small mammals there constituted but a small part of his investigations. He used five quadrats of small size — ten meters on a side, apparently following the suggestion of Shelford (1929, p. 55). These are referred to hereafter as 10-meter quadrats.

Aldrich (MS) also used the 10-meter quadrats, singly and in blocks of nine (thus forming a quadrat 30 meters on a side), in studying the small mammal populations of various communities of the hydrosere at Aurora Pond, Portage County, Ohio. His work began during the summer of 1933 and continued through 1934. No trapping was done at Aurora Pond during 1935, but since that year further studies, with larger quadrats, have been made annually by the writer and Dr. Aldrich.

Believing that the use of units as small as the 10-meter quadrats greatly increased the probability of error when they were used as bases for the estimation of actual numbers, the writer tried a number of different methods. In 1933 fifty-foot and 150-foot quadrats were operated synchronously at a number of stations and the results carefully compared. In 1934 the 50-foot and 10-meter sizes were compared, and in 1935, the 150-foot and 10-meter sizes. In 1936 the conclusions arrived at were carefully re-checked by another exhaustive comparison of the 10-meter and 150-foot sizes, on a far wider scale than heretofore. The smaller sizes were discarded thereafter, and work was continued with the 150-foot units. In 1938 the desirability of a "one-man quadrat" was fully recognized and trial was made of 100-foot units. In this year, and 1939, circular units of approximately the same area (½ acre) as the 150-foot sizes were tried, upon the recommendation of Dr. S. C. Kendeigh.

Various other modifications were also attempted: protective "shelter-belts" of traps and quadrats, insulated from the in-wanderings (drift) of small mammals by sheet-iron sunk into the ground to a depth of several inches. Full study was made of the yields of central quadrats in blocks of nine. A similar system was used by Elton, Davis, and Findlay in estimating the population of voles in Scotland (1935, p. 284). All these studies were made in many different habitats, and the quadrat-behavior of thirty species of small mammals was noted. The scientific names of the various species concerned are given in Table X. Elsewhere they appear as binomials. For the sake of uniformity and brevity the subspecific names are

omitted. In a few cases, as in the daily yield tables, more than one subspecies of the same animal are concerned in the averages, and in several others, the actual identity of the subspecies in question is still in doubt.

The population estimates as derived from each quadrat are given to the nearest whole animal; thus, a yield of 1 *Blarina* from a 150-foot quadrat is interpreted as 2 animals per acre instead of 1.94 animals. The average figures are given, however, to the nearest tenth or hundredth of a point.

FIELD METHODS

The method of quadrat trapping followed by workers from the Cleveland Museum of Natural History is as follows: a square of land of known area is marked off. Traps are set over the entire square, the number varying according to the needs of the terrain. They are placed in such a way that they will as quickly as possible drain the area of its resident and transient small mammal population. The traps are kept in operation for three days or until there is no further yield, or until the daily yield has reached a minimum. A field map of the quadrat is made, showing trap-sites, rocks, logs, etc. The record of each trap is kept on the map, while the daily catch is added up and tabulated on the back of map or on a separate sheet. When specimens are saved, the quadrats they came from are reported on the field tags along with the date and other data. Many different sizes and groupings of quadrats may be used, and the relative efficiency of the different methods varies. From the yield obtained per quadrat the number of animals per acre, per square mile, or any other large area, may be computed, providing the ecological conditions of the large area are uniform and similar to those in the quadrat.

In forest quadrats, ninety-five percent of the traps are set in underground runways which may be found by rapid probing or tapping with one's forefinger, and which can often be detected by an experienced field worker simply by walking over the terrain of the quadrats.

The number of traps set per quadrat depends entirely upon the terrain, but under all ordinary circumstances at least 12 traps are

placed in each 10-meter unit and at least 100 in each 150-foot (half-acre) area. Traps are *never* set at fixed intervals within the quadrat; they are placed where they will catch the mammals. Every effort is made to reduce the bait factor to a minimum by setting the traps in such a way that the mammal will be caught whether the trap is baited or not. Local conditions — that is, the underground runways, in which most traps are set — make bait unessential for the capture of all the insectivores and all the voles considered in this report. Bait (rolled oats or dried fruit) is usually used, however, except in the rainiest weather, in order to attract certain other species, notably the small sciurids and jumping mice, which do not habitually use runways. For the bait preferences of certain small mammals, the reader is referred to Townsend (1935, pp. 22-28).

The specialized technique used when we operated quadrats insulated from drift is considered later on in this report in conjunction with the data yielded by that type of quadrat.

COMPARISON OF THE YIELDS OF 10-METER AND 150-FOOT QUADRATS

The five 10-meter quadrats used at North Chagrin Metropolitan Park were operated for the purpose of studying small mammal populations per acre and population fluctuations from 1932 to 1936 inclusive, by Dr. Williams. Data obtained in all the years except 1936 have been published by that worker (1936, pp. 46-47). That for 1936 appears for the first time in this paper.

North Chagrin Metropolitan Park is very fully described as a Beech-Maple climax community (loc. cit.). Suffice it to say here that two of the five 10-meter quadrats (B and D, see Tables) were situated on points of land overlooking the valley of the Chagrin River, in situations where hemlock was an important member of the plant community. Conditions of soil and cover were typical of the forest as a whole in all but one of the quadrats (A) where there was a deficiency of cover and humus. Quadrat C was encompassed by a grid of nine 50-foot quadrats in 1935 and 1936 in an effort to study the effect on its yield of a shelter-belt of traps designed to exclude non-resident animals that drift into such small units during

TABLE I. Summary of Total Yields from 10-Meter Quadrats, North Chagrin Metropolitan Park, Cuyahoga County, Ohio. [In Part after Williams (1936, p. 46).]

Quadrat	Year	Blarina	Sorex fumeus	Sorex cinereus	Parascalops	Tamias	Sciurus huds.	Peromyscus leuc.	Microtus	Pitymys	Zapus	Napaeozapus	All Species
A.	1932	10	0	0	0	–	–	8	0	0	0	0	18
	1933	4	1	0	0	–	–	1	0	0	0	0	6
	1934	2	0	0	0	–	–	0	0	0	0	0	2
	1935	8	0	0	0	1	1	3	0	0	0	0	13
	1936	2	0	0	0	0	0	0	0	0	0	0	2
B.	1932	12	0	0	0	–	–	3	0	0	0	1	16
	1933	0	0	0	0	–	–	0	0	0	0	0	0
	1934	0	1	0	0	–	–	0	0	0	0	0	1
	1935	2	0	0	0	2	0	5	1	0	0	0	10
	1936	0	1	0	0	1	0	0	0	0	0	0	2
C.	1932	5	0	0	0	–	–	6	0	0	0	0	11
	1933	3	0	0	0	–	–	0	0	0	0	0	3
	1934	1	0	0	0	–	–	0	0	2	0	0	3
	1935*	2	0	0	0	0	1	0	0	1	0	0	4*
	1936*	0	0	0	0	0	0	0	0	0	0	0	0*
	1937*	0	1	0	0	0	0	0	0	0	0	0	1*
	1938*	1	0	0	0	0	0	0	0	0	0	0	1*
	1939*	0	0	0	0	0	0	0	0	0	0	0	0*
D.	1932	6	0	0	0	–	–	5	0	0	1	0	12
	1933	2	0	0	0	–	–	3	0	0	0	0	5
	1934	1	0	0	0	–	–	1	0	0	0	0	2
	1935	5	0	0	0	0	0	7	0	0	0	0	12
	1936	4	0	0	1	0	0	1	0	0	0	0	6
E.	1932	4	0	0	0	–	–	6	0	0	0	0	10
	1933	3	0	0	0	–	–	1	0	0	0	0	4
	1934	2	0	0	0	–	–	3	0	0	0	0	5
	1935	4	0	0	0	0	0	8	0	2	0	0	14
	1936	3	0	0	0	0	0	0	0	0	0	0	3
All Quadrats													
	1932	37	0	0	0	–	–	28	0	0	1	1	67
	1933	12	1	0	0	–	–	5	0	0	0	0	18
	1934	6	1	0	0	–	–	4	0	2	0	0	13
	1935	21	0	0	0	3	2	23	1	3	0	0	53
	1936	11	1	0	1	1	0	1	0	0	0	0	13

* See p. 26-28. – : no rat traps used.

trapping operations. Hence, its yields are not strictly comparable to those of the others during these two years, but are of interest nevertheless.

Table I gives a summary of the total yields during approximately twelve days time from these 10-meter quadrats. Total yields are here given instead of the yields during a shorter period because the table is an enlargement of one used by Dr. Williams (1936, No. 12, p. 46), who based his population estimates on the sum and total of all specimens taken during the period of trapping. Evidence is given subsequently in this paper that estimates should be based on the yields during only the first three days of trapping. It will be noted that the lack of humus and cover characteristic of quadrat A had no apparent effect on its yields, probably for the reason that it was well within the normal wandering range of numerous small mammals whose incursions into the area were of temporary nature. It will also be noted that the yields of quadrat C from 1935 on are much lower than the yields for the corresponding years from the other units, because of the "shelter-belt" surrounding it.

In these figures summarizing the results of all the quadrats it may be seen that small mammal populations were great in 1932 and 1935, indicating that these years probably marked peaks of small mammal abundances. Closer inspection of the data, however, reveals that the character of the peaks was determined almost entirely by two species, the short-tailed shrew, and the deer mouse. The more unusual species do not seem to follow the same curve.

In Table II are found population-estimates per acre for each species, based in part on the figures in Table I. There the numerical changes may be more easily visualized. It will be shown subsequently that these figures are in all probability far higher than they should be, but as the sources of error are common to all, the figures are comparable to each other with the possible exception of those of quadrat C from 1935 to 1939. They show two definite peaks in the populations of at least two species, and provide the first evidence of a short-wave cycle of about three years among the woodland small mammals of our latitudes in North America. Subsequently, as is shown in Table II, evidence was gathered that seems to show that *Blarina* is either non-cyclical or has a cycle of a length as yet not definitely determined. The figures of Townsend (1935, p. 48)

give population-estimates per acre for the years 1931-1934, but do not entirely bear out the existence of such a cycle in all communities. The increased populations in certain habitats during the years 1931 and 1932 he ascribes to factors influencing the moisture and hence humidity of the community, and cites figures showing that in certain habitats, such as very moist woods, there is a remarkable constancy of populations from year to year. He believes that certain small mammals may migrate into the moister areas during dry periods, a feature noted by numerous other workers, including the writer. It is to be expected, however, that cyclical changes in small mammal populations are more likely to be noted in areas not permanently suited to small-mammal occupancy; and the writer believes that Townsend's figures lend considerable support to the fast-accruing evidence of the existence of cycles for certain species.

In 1935 a grid of 50-foot quadrats, numbering nine in all, actually constituting a quadrat 150-feet on a side, was operated at the site of 10-meter quadrat C, which formed the center of the central unit of the grid. Such grids had been used as early as 1933 by the writer, but it was not until two years later that grids were operated at the same station with 10-meter units. The purpose of the grid was to study the yield from the center quadrat, which it was hoped would provide accurate figures on small mammal populations from an area protected from drift (by the outside quadrats). However, it was soon discovered that it was virtually impossible to get a fair cross-section of a given population from such central quadrats, while the entire grid usually gave a very complete picture. The data obtained in 1935 from the North Chagrin grid are given in Tables II, IV, and V.

The yield for the 10-meter quadrats (Table III) and the 150-foot grid (Table IV) are compared in Table V. In all such grids treated in this report, No. 5 is the central 50-foot unit and Nos. 1, 3, 7, and 9 are corner quadrats. It will be seen that the five 10-meter quadrats (Table III) captured nearly two-thirds as many animals within three days as the grid (Table IV), although their combined areas amounted to less than one-quarter of the grid's area. Consequently, the figures per acre for each species are very much greater when based on the smaller units. Since drift into the grid has not been completely stopped by any means, the figures obtained from it are

TABLE II. Populations-per-acre based on Total Yields from Five 10-Meter Quadrats and the 3-day Yields from 150-foot Quadrats in Beech-Maple Forest at North Chagrin Metropolitan Park.

Quadrat and Year	Blarina	Sorex fumeus	Sorex cinereus	Parascalops	Condylura	Tamias	Glaucomys	Sciurus huds.	Peromyscus leuc.	Microtus	Pitymys	Zapus	Napaeozapus
10-Meter.													
1932	296	..	..	P	..	P	P	P	224	..	..	8	8
1933	96	8	..	P	P	P	P	P	40	..	..	..	..
1934	48	8	..	P	..	P	P	P	32	..	16	..	..
1935	184	..	..	P	..	24	P	16	216	8	24	..	..
1936	89	8	P	8	..	8	P	P	8	..	16	..	..
150-Foot.													
1932*	42	..	..	?	..	?	?	?	32	..	..	P	P
1933*	17	2	..	?	..	?	?	?	6	..	..	..	..
1934*	7	2	..	?	..	?	?	?	5	..	3	..	..
1935	29	..	..	2	..	4	P	P	27	..	17	..	..
1936	18	6	2	P	..	2	2	P	2	..	2	..	..
1937	40	10	4	10	..	P	P	P	8	..	..	..	4
1938**	29	3	..	P	..	1	1	?	20	..	4	..	..
1939**	12	7	..	5	..	1	P	..	2	..	4	..	..

* Figures from corrections made on 10-Meter yields, the proper corrections determined from the relative yields of 10-Meter and 150-Foot quadrats in 1935 and 1936 at this station.

** 2 quadrats in average.

Blank : no records for year. P : population below 8 per acre (10-Meter) or 1 or 2 (150-Ft.).

? : present, but reliable figures lacking.

certainly not too low, even taking into account the fact that a small number of animals escape, or drag traps into places from which they cannot be recovered. Such occurrences are rare and are usually omitted in compiling the data here given, although in the case of moles, these are carefully taken into account. Elton (1935) and co-workers, Hamilton (1937) and other workers have overcome this

difficulty by the use of traps that captured their animals alive, a method preferable from many points of view, but too time-consuming for the worker who wishes to cover large sections of the country in a short space of time. The grids, as was mentioned above, were set up with the idea that the central quadrat would have the drift eliminated and that an accurate picture of the inhabitants of the quadrat could thus be obtained. This is undoubtedly true, at least as compared to quadrats unprotected from drift; but an attempt to base the total population of a large area on only one such unit gives the anomalous results indicated in Table V. It happened, in the case of quadrat C-5, that an infestation of *Pitymys* was centered in that locality, and that the population of *Blarina* was somewhat denser than usual. But in the first three days, no *Peromyscus* was taken, indicating a total lack, in that small unit, of one of the most abundant and characteristic mammals of the North Chagrin woods. However, if many such central quadrats are averaged (See Table VI), from similar woods in different localities with the same general

TABLE III. 1935 3-Day and Total Yields from the five 10-Meter Quadrats at North Chagrin Metropolitan Park, Cuyahoga County, Ohio. Total Yields in Parentheses. For the distribution of these quadrats, see p. 26.

Species	A	B	C	D	E	Totals
Blarina brevicauda.....	3 (8)	2 (2)	1 (2)	3 (5)	3 (4)	12 (21)
Peromyscus leucopus...	0 (3)	2 (5)	0 (0)	2 (7)	2 (8)	6 (24)
Pitymys pinetorum.....	0 (0)	0 (0)	1 (1)	0 (0)	2 (2)	3 (3)
Sciurus hudsonicus.....	1 (1)	0 (0)	0 (1)	0 (0)	0 (0)	1 (2)
Tamias striatus.....	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	1 (2)
Microtus pennsylvanicus	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (1)
Totals, All Species.....	4 (12)	5 (10)	2 (4)	5 (12)	7 (14)	23 (52)

Quadrat C was situated at the center of the 150-foot grid (See Table IV and pp. 26-28). The drift it would normally have captured was collected by the outer portions of the grid; hence, the yields for this particular quadrat were much lower than those of the others. There is evidence to show that some of its residents drifted *outwards* and were taken in the grid.

The area of the five 10-meter quadrats is 0.123 acre. The total trapping time for each of the five quadrats was nine days in 1935.

TABLE IV. 1935 Record of the North Chagrin Park 150-Foot Quadrat (Grid of nine 50-Foot Units); the 3-Day and Total (9-Day) Yields, the latter in parentheses. Area of Grid, 0.516 acre.

Species	C-1	C-2	C-3	C-4	C-5*	C-6	C-7	C-8	C-9	Totals
Blarina brevicauda....	4 (6)	0 (0)	1 (3)	1 (1)	3 (4)	1 (1)	1 (1)	3 (4)	1 (1)	15 (21)
Peromyscus leucopus..	3 (4)	0 (0)	3 (5)	1 (2)	0 (4)	1 (2)	3 (4)	0 (1)	3 (4)	14 (26)
Pitymys pinetorum...	1 (1)	0 (0)	0 (0)	1 (3)	5 (5)	2 (3)	0 (0)	0 (0)	0 (0)	9 (12)
Sciurus hudsonicus....	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (1)	0 (2)
Tamias striatus.....	0 (0)	2 (2)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)
Glaucomys volans....	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)
Totals, All Species....	8 (11)	1 (2)	4 (8)	3 (6)	8 (14)	4 (6)	4 (5)	3 (5)	4 (7)	40 (64)

*Center quadrat of grid. This quadrat includes the 10-Meter quadrat C (See p. 26 and Table III). The figures here given include those for 10-Meter quadrat C as given in Table III. It is a matter of chance, however, that the yields from C-5 are the largest of any of the grid quadrats.

**Quadrat C-2 contained the only chipmunk citadel (using this word in the sense of Grinnell). It is noteworthy that no other species was taken in its immediate vicinity.

TABLE V. Comparison of Population Estimates based on Yields of the North Chagrin 10-Meter and 150-Foot Quadrats in August, 1935.

	Blarina	*Peromyscus*	*Pitymys*	*Tamias*	*Sciurus huds.*
Population per acre, based on the 10-Meter 3-day Yields.	97	49	24	8	8
Population per acre, based on the 10-Meter Total Yields.	184	216	24	24	16
Population per acre, based on the 150-Foot 3-day Yields.	29	27	17	4	2
Population per acre, based on the 3-day Yield of C-5 only (the center quadrat of grid)	53	....	85	....	....
Population of the 65-acre area, based on the 10-Meter 3-day Yields.....	6341	3171	1585	538	538
Population of the 65-acre area, based on the 10-Meter Total Yields.....	11097	12602	1585	1076	1076
Population of the 65-acre area, based on the 150-Foot 3-day Yields.....	1890	1754	1224	254	....
Population of the 65-acre area, based on the 150-Foot Total Yields.....	2856	3536	1632	254	254

population figures, the picture becomes more normal, and, as is to be expected, the estimates per acre run on the average below those obtained from 150-foot quadrat data; in fact, for several species in Table VI there are no records at all for the center quadrats, a situation which may be partially duplicated if any other quadrat of the grid is taken in place of the central one. However, the fact that the outside quadrats always show a *slightly* better picture than the centers indicates that drift is at work, and is an argument for a very short trapping period. Thus, the number of grids necessary to provide good average data for the center quadrats is very great. Most workers using quadrats have indicated the necessity of obtaining

figures from a large number of quadrats when working on the relative abundance of organisms, as were Raunkaier (1918), Gleason (1920), Kenoyer (1927), and Dice (1931 and 1938). This holds equally true for workers interested in actual abundance. A difficulty arises in the fact that in order to obtain sufficient records of central quadrats from one and the same tract of woodland or field, which is to be preferred over quadrats in different districts, a great deal of time must be spent and the resultant depopulation arising from the use of many grids would be considerable and conceivably might seriously alter the ecological picture. Furthermore, as Dice points out (1938, p. 125) it seems wasteful of time and data not to use the information accruing from the sheltering tier of quadrats themselves. The utility of a central quadrat might be greatly increased if enlarged from 50, to let us say, 150 feet or more, but modifications in the shelter-belt must then be made or the usefulness of the method will speedily collapse. Some further observations on shelter belts will be made later on in this report.

Table VI. Population Estimates based on the Yields of fourteen 150-Foot Grids, each of nine 50-Foot Quadrats, and on the Yields of the Central Quadrats of these Grids. All Data secured in 1938 in Climax Forests.

Quadrat	Blarina brevicauda	Sorex fumeus	Sorex cinereus	Parascalops breweri	Condylura cristata	Tamias striatus	Glaucomys volans	Sciurus hudsonicus	Peromyscus leucopus	Microtus pennsylvanicus	Pitymys pinetorum	Zapus hudsonius	Napaeozapus insignis
Centers..	12.6	10.9	0	1.2	0	0	0	0	18.2	1.2	1.2	0	3.8
Grids....	34.2	9.7	0.14	1.1	0.28	1.1	1.6	0.14	22.2	0.28	2.9	0.14	1.6

THE YIELDS OF 50-FOOT AND 10-METER QUADRATS

In 1933 the writer believed that the accuracy of a quadrat could be greatly increased if the size of the unit used were increased by using 50-foot instead of 10-meter units. The area of a 10-meter quadrat is but 1/41 of an acre, while that of one 50-feet on a side is approximately 1/17. The increase seemed quite important and a great deal of data was secured during 1933 and 1934 with the use of the new size of quadrat. It seems unnecessary to compare in detail the yields of the two sizes; it will suffice to report that in any given year the yields from the 50-foot units were in general slightly the greater, the yield of the larger units being to those of the smaller as 6 to 5, instead of 2.5 to 1, as one might expect from the relative areas of the two units. The average daily yield from the two sizes is compared in Fig. 2. The fact that the 50-foot line is usually below the 10-meter line is due to the fact that the 10-meter line covers two "mouse years", 1932 and 1935, while the 50-foot data was almost all gathered in 1933 and 1934, years of low small mammal populations. The point to be gained from this may be much better emphasized by comparing the 50-foot yields with those of the 150-foot quadrats, the contrast in which is of similar order as that between the 10-meter and 150-foot units. At Little Mountain, Geauga County, Ohio, a series of 50-foot quadrats and 150-foot grids were operated synchronously. As a check on the North Chagrin data, let us consider that obtained at Little Mountain.

THE YIELDS OF 50-FOOT AND 150-FOOT QUADRATS COMPARED

Trapping was carried on at Little Mountain with these two units in 1933, an ebb-cycle year further characterized by great drought. Since 1935 only the larger units have been used. The actual field technique was the same as was used at North Chagrin and elsewhere. The presence of Mr. Philip N. Moulthrop as field assistant, who had done the bulk of the trapping at North Chagrin, tended to standardize the trapping technique and eliminate error due to the varying experience of different workers. This error is chronically brought

up as an objection or a difficulty to be encountered in assembling quadrat and other trapping data, vide Dice (1931) and Ruhl (1932). In this connection, it might be well to mention that any differences in trapping technique speedily manifest themselves in the yields of the quadrats. In the course of this work, every field assistant is given a rigid course of training before being allowed to trap inside quadrats, and the yields of each trapper are carefully and continuously examined. The most efficient trapper is he who gets the most small mammals of *all* species in a given area in the shortest time. No great deviation below this can be tolerated, and it has been found that well-trained workers do not deviate in their outputs to any appreciable extent.

The numbers of the different sizes of quadrats used at Little Mountain were: in 1933, eight isolated 50-foot units and three 150-foot grids; and in 1935, four 150-foot grids only, and three grids only from 1936 to 1939 inclusive. In 1933 and 1935 trapping was done for comparable lengths of time in the early summer. From 1936 on the quadrats were worked for but little longer than three days.

Grids of quadrats were maintained as follows: one in a nearly pure hemlock community, the "hemlock block" hereinafter mentioned; one in white pine woods, the "pine ridge" block; one in a second-growth oak-chestnut area on the central "saddle" of the mountain where pines are invading, the "pine seedling" block; and one in a beech-cucumber area, the "beech-cucumber" block. Except for the lattermost, all were worked in both 1933 and 1935. The beech-cucumber block was completely worked only from 1935 on, although two of its corner quadrats were worked in 1933 as isolated 50-foot units. During 1936 and 1937 the hemlock and pine-seedling grids were discontinued, and in their place there was substituted the "Daley's Field" grid in a woods-edge community of sumacs, aspens, young red maples, pine, and Kentucky coffee trees. The hemlock quadrat was revived in 1938 and 1939 in place of this unit.

A chart summarizing the results obtained in 1933 and contrasting the yields of 50-foot and 150-foot units constitutes Table VII. It will be seen that the average per 50-foot solitary quadrat is higher in all cases than the averages for the grids, for the two species that appeared in the three-day totals in both the grids and the solitary units. This also raises the estimate per acre and hence the estimate

for the population of the seventy-five acre area under consideration, as indicated. Thus further evidence is provided that the estimates based on small units are always larger than those based on larger ones.

Remembering that the estimates per acre given in Table VII are based on a three-day, and not on a total yield, the population per acre of *Blarina* and *Peromyscus* on Little Mountain in 1933, as furnished by the data in this table, may be compared to the figures given by Williams, for 10-meter quadrats as recorded in Table II, for those species at North Chagrin in the same year. It will be noted that the divergence in figures per acre between North Chagrin and Little Mountain is tremendous. At that time the writer felt that the North Chagrin woodland naturally had a much higher number of resident small mammals than did Little Mountain, even taking into account the sources of error already mentioned. However, the results of our 1935 and subsequent work with large grids indicate no actual fundamental differences (see Tables V and IX) between the two communities.

Table VIII gives the actual yield from each of the three grids used in both 1933 and 1935 on Little Mountain. They help to give an idea of the size of the series of specimens on which the total population is based. This total (Table VII) is obtained from the average figures for the three grids, here considered as three large quadrats.

Corroborating the North Chagrin records insofar as relative abundances and increase are concerned is the fact that the populations of *Blarina* and *Peromyscus* underwent an increase of roughly 400 percent between 1933 and 1935. The appearance of many more species in the three-day totals for 1935 than for 1933 is another indication of a general increase not confined to any one species. The fact that chipmunks and flying squirrels were not taken in 1933 is due, however, to our not having used rat-traps regularly in that year.

The writer feels that the estimate for *Pitymys* is approximately correct, but that the one for this vole obtained by the grid-census at North Chagrin in 1935 is somewhat too large owing to the fact that the grid apparently encompassed a colony. The 10-meter quadrats (Table I) at North Chagrin tend to show that *Pitymys* is less generally distributed than either *Blarina* or *Peromyscus* and that

the population is not generally as dense as in the 150-foot quadrat, further indication of the fact that more than one quadrat, of any given size, should be used if population estimates for a larger area are to be made. In this connection, attention is called to Table IX (pp. 41-42), wherein the summarized estimates for all the 150-foot quadrats on Little Mountain are recorded. It will be noticed that in certain cases, notably those of *Blarina* in the pine ridge and beech-cucumber grids, the yearly records from a single 150-foot quadrat do not indicate the same cyclical tendency that the averages from several quadrats do. Similarly, it will be seen that the estimates based on the center quadrats are irregular and hopelessly out of step with those based on the grids. The figures, to the writer's mind, entirely remove the central-quadrat method from the field of reliability except under certain conditions already enumerated. A 50-foot quadrat, even if sheltered from drift, can give no picture with any degree of completeness of the small mammal population of a large area, and if sheltered from drift from the outside has nothing to prevent drift out of itself. The estimates tend to be inflexible and either too high or too low as compared to the estimates based on the large units. Thus, the smallest possible figure obtainable from a single 50-foot unit is 17 per acre, on the basis of one animal captured. The averages from a very large number of centers give a better picture, but the difficulties accruing to this method have already been pointed out. From the central quadrat of the hemlock block it would appear that the *Peromyscus* population diminished by half from 1933 to 1935, the exact reverse of the situation as recorded in all other quadrats, protected and unprotected. Another conclusion that might be pointed out from the above and that has already been indicated is that the population of the more generally distributed species seems to be more or less constant in northeastern Ohio, during a "mouse year", or increase of the cycle, from woodlot to woodland and from one climax forest type to another (See Table IX, pp. 41-42).

TABLE VII. Summary of the Quadrat-Trapping Work on Little Mountain in 1933.

Species	3-Day and (Total) Yields from 8 isolated 50-foot quadrats	Ave. per quadrat of the 8 isolated units (based on 3-day yield)	Ave. number per quadrat of Pine-Ridge grid of nine 50-foot quadrats	Ave. number per 50-foot quadrat of Pine-Seedling grid	Ave. number per 50-foot quadrat of Hemlock grid	Population of 75-acre area, based on 3-day yields of isolated 50-foot units	Population of area based on 3-day yield from grids (150-ft.)	Population of area based on center quadrats of the three grids	Population per acre based on 3-day yields from isolated units (left) and from grids (right)	
Blarina brevicauda.....	3 (15)	0.375	0.22	0.22	0.33	490	324	....	6.4	4.3
Sorex fumeus fumeus.....	0 (1)	....	....	0.22	0.44	....	279	444	...	4.0
Peromyscus leucopus.....	8 (16)	1.00	0.67	0.33	0.67	1308	693	1333	17.2	9.3
Napaeozapus insignis.....	1 (3)	0.125	....	....	....	163*	....	....	2.2**	...
Tamias striatus.....	0 (1)	....	....	....	....	....	....	....	...	...
Sciurus hudsonicus.....	0 (1)	....	....	....	....	....	....	....	...	...

*Too high an estimate, as the Woodland Jumping Mouse is limited to wet ground.

**For wet, cool areas only.

Attention is called to the estimates based on the center-quadrats and the isolated 50-foot units as compared to those based on the 150-foot grids taken as units.

TABLE VIII. The Yields of Three 150-Foot Quadrats on Little Mountain for the Years 1933 and 1935.

Species	Pine-Ridge		Pine-Seedling		Hemlock		Totals	
	1933	1935	1933	1935	1933	1935	1933	1935
Blarina brevicauda.....	2 (13)	7 (44)	2 (8)	15 (30)	3 (6)	10 (30)	7 (27)	32 (104)
Sorex fumeus fumeus.....	0 (2)	1 (5)	2 (2)	2 (5)	4 (10)	4 (14)	6 (14)	7 (24)
Parascalops breweri.....	0 (0)	1 (3)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	1 (4)
Peromyscus leucopus.....	6 (9)	17 (41)	3 (7)	10 (22)	6 (11)	21 (49)	15 (27)	48 (112)
Pitymys pinetorum.....	0 (0)	1 (5)	0 (0)	4 (8)	0 (0)	0 (1)	0 (0)	5 (14)
Mus musculus.....	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)
Tamias striatus.....	0 (0)	8 (23)	0 (0)	2 (6)	0 (0)	4 (8)	0 (0)	14 (37)
Sciurus hudsonicus.....	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	1 (3)
Glaucomys volans.....	0 (0)	2 (4)	0 (0)	2 (5)	0 (0)	2 (5)	0 (0)	6 (14)

Trapping-times: Pine-Ridge, 22 days in 1933, 18 in 1935; Pine-Seedling, 17 days in 1933, 16 in 1935; Hemlock, 11 days in 1933, 17 in 1935. Average for all quadrats: 16⅔ days in 1933, 17 in 1935.

TABLE IX. Populations-per-acre in different Forest Communities on Little Mountain, Geauga and Lake Counties, Ohio. Figures Based on the 3-Day Yields of 150-Foot Grids and their Central 50-Foot Quadrats.

QUADRAT and YEAR	Blarina	Sorex fumeus	Parascalops	Tamias	Glaucomys	Sciurus huds.	Peromyscus leuc.	Microtus	Pitymys	Synaptomys	Mus	Napaeozapus
PINE RIDGE												
Grid												
1933	4	..	..	..	..	..	12	..	..	..	..	..
1935	14	2	2	16	4	..	34	..	..	..	..	..
1936	18	4	4	2	..	..	..	..	4	..	..	..
1937	20	16	..	..	..	..	10	..	..	..	..	..
1938	22	12	..	2	4	..	10	..	4	..	..	..
1939	26	18	4	2	..	..	..	..	..	..	..	..
Center												
1933	..	..	..	..	..	..	..	..	..	..	..	..
1935	17	..	..	..	..	..	17	..	..	..	..	..
1936	..	..	..	..	..	..	..	..	..	..	..	..
1937	17	..	..	..	..	..	17	..	..	..	..	..
1938	..	17	..	..	..	..	..	..	..	..	..	..
1939	..	..	..	..	..	..	..	..	..	..	..	..
PINE SEEDLING												
Grid												
1933	4	4	..	..	..	..	6	..	..	..	..	..
1935	28	4	..	4	4	..	20	..	8	..	..	..
Center												
1933	..	..	..	..	..	..	..	..	..	..	..	..
1935	17	..	..	..	..	..	..	..	..	..	..	..
HEMLOCK												
Grid												
1933	6	8	..	..	..	..	12	..	..	..	..	..
1935	20	8	..	8	4	2	42	..	..	..	..	..
1938	8	12	..	4	..	2	16	..	..	..	..	..
1939	12	18	..	2	..	..	4	..	..	..	2	..
Center												
1933	..	..	..	..	..	..	34	..	..	..	..	..
1935	..	..	..	..	..	..	17	..	..	..	..	..
1938	17	..	..	..	..	..	..	..	..	..	..	..
1939	17	17	..	..	..	..	..	..	..	..	..	..
DALEY'S FIELD												
Grid												
1935	24	2	4	8	2	2	34	4	6	4	..	..
1936	12	..	24	10	..	..	..	..	..	..	..	..
1937	34	..	12	2	4	..	18	..	..	..	..	2
Center												
1936	17	..	..	..	..	..	..	..	..	..	..	..
1937	..	..	..	..	..	..	51	..	..	..	..	..

Quadrat and Year	Blarina	Sorex fumeus	Parascalops	Tamias	Glaucomys	Sciurus huds.	Peromyscus leuc.	Microtus	Pitymys	Synaptomys	Mus	Napaeozapus
Beech-Cucumber												
Grid												
1935	38	8	2	6	4	4	22	..	4	..	..	..
1936	32	16	6	4	..	..	4	..	..	..	..	..
1937	24	24	4	2	..	..	16	..	..	..	..	..
1938	30	58	8	4	4	..	22	..	..	..	..	..
1939	22	32	4	..	..	..	2	..	..	..	..	..
Center												
1935	..	..	17	..	..	..	17	..	..	..	..	..
1936	..	..	..	..	..	..	..	..	..	..	..	..
1937	..	17	..	..	..	..	34	..	..	..	..	..
1938	..	85	..	..	..	..	17	..	..	..	..	..
1939	..	..	..	..	..	..	..	..	..	..	..	..
Averages, All Quadrats												
Grid												
1933	4.7	4.0	P	0.4	P	P	9.7	..	P	..	P	P
(1934)*	(10.0)	(4.5)	(3)	1.9	(P)	0.5	(15)	..	(1.5)	..	(P)	..
1935	24.8	4.8	2.6	8.4	3.6	3.6	30.4	0.8	4.5	0.8	P	..
1936	15.2	6.3	4.7	P	P	P	3.3	P	1.3	..	..	..
1937	25.0	12.7	4.7	P	P	P	14.7	..	P	..	..	0.6
1938	20.0	27.3**	2.7	3.3	2.7	0.7	16.0***	..	1.3	P	P	..
1939	20.0	22.7	2.7	1.3	..	P	2.0	..	P	..	0.7	..
Center												
1933	5.6	5.6	..	..	..	..	17.0	..	..	..	..	..
1935	****8.5	..	..	..	..	..	12.7	..	..	..	..	..
1936	17.0	..	..	..	..	..	5.6	..	..	..	..	..
1937	5.6	5.6	..	..	..	..	34.0	..	..	..	..	..
1938	5.6	34.0	..	..	..	..	5.6	..	..	..	..	..
1939	5.6	5.6	..	..	..	..	..	..	..	..	..	..

*Figures for 1934 are hypothetical when parenthesized, and are based on yields at other stations. Otherwise the 1934 figures are based on spot censi.

**Peak Population not duplicated at other stations than Little Mountain. Elsewhere, 1937 was peak year for *Sorex fumeus*.

***Peak much lower than elsewhere, due to failure of key food crop in 1937 (acorns). At other forest stations, Beech and Sugar Maple predominate; they are rare on Little Mountain.

****Does not include figures for Daley's Field, which was not a grid in this year.

P Present, but in populations too low to be measured by only three or four quadrats.

Key to Forest Communities: Pine Ridge, *Pinus-Acer* Facies of *Pinus-Tsuga* Association; Pine Seedling, *Quercus-Castanea* Association with understory of young white pines; Daley's Field, a Woods-Edge Community (*Acer-Populus Associes*); Beech-Cucumber, *Fagus-Magnolia* Facies of *Acer-Fagus* Association. See p. 36.

TABLE X. Check-list of the Mammals Mentioned in This Report. Names for the most part are taken from "List of the Mammals of Ohio," Ohio State Mus. Mimeographed Bull. No. 1, by E. S. Thomas and B. P. Bole, Jr., February, 1938.

Common or Virginia Opossum	*Didelphis virginiana virginiana* Kerr
Smoky Shrew	*Sorex fumeus fumeus* Miller
Canada or Masked Shrew	*Sorex cinereus cinereus* Kerr
Thompson Pigmy Shrew	*Microsorex hoyi thompsoni* (Baird)
Common Short-tailed Shrew	*Blarina brevicauda brevicauda* (Say)
Old-field Shrew or Little Short-tailed Shrew	*Cryptotis parva* (Say)
Prairie Mole	*Scalopus aquaticus machrinus* (Rafinesque)
Hairy-tailed Mole	*Parascalops breweri* (Bachman)
Star-nosed Mole	*Condylura cristata* (Linnaeus)
Eastern or Common Raccoon	*Procyon lotor lotor* (Linnaeus)
Eastern Skunk	*Mephitis mephitis nigra* (Peale and Beauvois)
Allegheny Least Weasel	*Mustela rixosa allegheniensis* (Rhoads)
New York Weasel	*Mustela frenata noveboracensis* (Emmons)
Eastern Red Fox	*Vulpes fulva fulva* (Desmarest)
	(This species and the next are not distinguished in the text)
Eastern Gray Fox	*Urocyon cinereoargenteus cinereogenteus* (Schreber)
Middle-Eastern Chipmunk	*Tamias striatus fisheri* Howell
	(In a few cases the form *lysteri* is also included under *Tamias*)
Middle-Eastern Red Squirrel	*Sciurus hudsonicus loquax* Bangs
	(Unless otherwise specified, all records of *Sciurus* refer to this form)
Northern Gray Squirrel	*Sciurus carolinensis leucotis* (Gapper)
Middle-Western Fox Squirrel	*Sciurus niger rufiventer* Geoffroy
Middle-Eastern Flying Squirrel	*Glaucomys volans volans* (Linnaeus)
Prairie White-footed Mouse	*Peromyscus maniculatus bairdi* (Hoy and Kennicott)
Northern Deer Mouse	*Peromyscus leucopus noveboracensis* (Fischer)
Stone's Lemming or Lemming-Vole	*Synaptomys cooperi stonei* Rhoads
Eastern Meadow-Mouse or Field-Vole	*Microtus pennsylvanicus pennsylvanicus* (Ord)
Mole Pine-Mouse or Pine-Vole	*Pitymys pinetorum scalopsoides* (Audubon and Bachman)
Common House Mouse	*Mus musculus musculus* Linnaeus
Norway or Barn Rat	*Rattus norvegicus* (Erxleben)
Hudson Bay Jumping Mouse	*Zapus hudsonius hudsonius* (Zimmerman)
Woodland Jumping Mouse	*Napaeozapus insignis insignis* (Miller)
Eastern Cottontail Rabbit	*Sylvilagus floridanus mearnsi* Allen

EXPERIMENTS WITH QUADRATS INSULATED BY SHEET-IRON

The method of enclosing quadrats with galvanized iron sheeting to exclude drift was first attempted with the aid of Dr. S. C. Kendeigh at the Baldwin Bird Research Laboratory in August, 1934. A 50-foot quadrat was selected, and a trench dug completely around its borders to a depth of from six to ten inches. Galvanized iron sheeting three feet in height was set in these trenches, which were purposely dug below the level of mole and pine-mouse runways. The sheeting was supported by being nailed to small posts that did not reach the top of the sheeting. The sheeting was nailed to inward side of the posts so that any mammal desiring to leave the quadrat could not jump up to the tops of them or climb them. Previously Dr. Kendeigh had determined the height to which deer mice (*Peromyscus leucopus*) could jump. This he accomplished by placing live mice in garbage pails whose sides were one foot high and two feet high respectively. Two placed in a one-foot container escaped at once. Of ten animals, both adults and young, placed in a two-foot container, only one succeeded in escaping and apparently did so by running centrifugally around the rusty walls of the can until the top was reached. The highest jump made by excited mice did not exceed eighteen inches. Thus it was believed that the additional nine or ten inches afforded by the iron sheeting constituted defense against drift.

After the sheeting was installed, the trenches were refilled and the ground about the sheeting was tamped down hard, to make excavation as difficult as possible. Finally collars of tin sheeting were placed about every tree inside the quadrat and all those immediately outside, to prevent species of arboreal tendencies, such as *Tamias* and *Peromyscus*, from entering or leaving by this route. Traps were then set throughout the quadrat and about the bases of each post supporting the sheet-iron, while a few were placed about the bases of nearby trees unprotected by sheeting.

The result of all this elaborate preparation was exactly zero in 1934. It seemed quite possible to the writer that no small mammals would stay in a 50-foot area while posts were being pounded and sheet-iron rattled for the better part of a day. However, the experi-

ment seemed well worth trying, and it must be said that there was virtually no recent small mammal sign whatever in the quadrat.

The attempt was resumed in a different place next year, complete in every detail. It should be remembered that the purpose of the sheet-iron was to exclude drift and that therefore, if the sheeting shut off all runways, the total yield should give the exact population of the 50-foot unit. The traps placed outside the quadrat along the bases of the posts and trees might be expected to catch the drift animals that would otherwise have been taken in the quadrat in the absence of the sheeting. Some idea of the proportion of drift to inhabitants should thus be obtained, realizing that any animal happening to be in the quadrats at the time they are set up is considered "resident".

From Table XI, it will be seen that just one *Blarina* was taken inside the sheeting, on the third day of trapping. During the five days that the traps were kept working, four *Blarina*, four *Peromyscus*, and one *Pitymys* approached the quadrat and were captured outside the sheeting and in its immediate vicinity, all these exterior traps being less than ten feet from it. Of these nine animals, six were taken in the first three days and two on the last two. It is possible that some of these were animals dispossessed during the installation of the metal.

One *Blarina* per 50-foot quadrat indicates a density of 16 or 17 individuals per acre, rather lower than the average of figures obtained from other sources. The fact that no other species whatever were taken in the quadrat seemed to suggest again that the animals might have left due to the disturbance attendant upon the installation of the sheeting. It was therefore decided to leave the quadrat as it was except for removing four eight-foot sections of iron, one on each side, to permit animals to go in and out. It was decided to allow the quadrat to become "naturalized" in this way for a few months, and then to return and quickly install the few remaining sections which would entail a minimum of disturbance.

Accordingly, in November, 1935, Mr. Moulthrop returned to the quadrat and installed the four missing sections. There had been a fall of leaves since the summer work, and conditions in general were more favorable for small mammals. The trapping was complicated by several falls of snow, which covered the traps to a depth of

six inches on one occasion. The traps were run from November 27th to December 5th, inclusive. During this time no less than 13 *Blarina* were taken inside the quadrat; 2 *Parascalops* and 2 *Pitymys* also were captured before all signs of activity ceased. In the peripheral traps on the outside of the sheeting, the "drift" consisted of 8 *Peromyscus* in the same length of time. The astonishing yield of shrews came almost entirely in the first five days, the trapping on the second, third, and fourth days having been almost entirely stopped by snow and hard rains. Ten of the *Blarina* and 2 *Pitymys* were taken within three days of actual trapping. Both moles eluded capture until the seventh and ninth days of trapping, and Mr. Moulthrop believes that a third animal was left uncaught.

These results are not surprising, in consideration of the inability of 50-foot quadrats to give a fair sample of the population of a large tract of woodland or field. The *Blarina* yield would give a population of 217 animals to the acre, a concentration highly unlikely in view of the summer's trapping records. Furthermore, no *Blarina* were taken outside the quadrat in November. This seemed to mean that the number of shrews within the quadrat was for some reason unusually high, perhaps because of the insect concentration, which was very conspicuous as compared to the ground outside the quadrat.

It may be suspected that the sheeting insulation "leaked," and that the *Blarina* were really drifting in under it. All that can be said in answer to this is that not a sign of tunneling under the sheeting was discovered either in 1934 or in 1935. By 1936, however, there was definite evidence that considerable tunneling had taken place under the sheeting, and it was reset. In addition to the animals captured inside the quadrat (see Table XI), several *Peromyscus* were captured outside the iron sheeting, as was the case in 1935. In 1937 further evidence of leakage was found and the tunnels were plugged. The results obtained in these two years in general seem to corroborate a deduction that was obvious as early as the fall of 1935 — that the metal quadrats acted as a trap of sorts for insectivores, especially for *Blarina*. It is difficult to see just why a shrew should be less able to find its way out of one of these quadrats (open in four small sections) than into it, but such seemed to be the case, to judge from the records. The explanation lies in the fact that moles plough up

TABLE XI. Yields of Control and Insulated Quadrats Compared (50-Foot Size). Estimates-per-acre, based on 3-Day Yields in the Controls and on Total Yields in the Insulated Units.

Species	1935						1936						1937*					
	Control			Insulated			Control			Insulated			Control			Insulated		
	3-Day Yield	Total Yield	Est. per Acre	3-Day Yield	Total Yield	Est. per Acre	3-Day Yield	Total Yield	Est. per Acre	3-Day Yield	Total Yield	Est. per Acre	3-Day Yield	Total Yield	Est. per Acre	3-Day Yield	Total Yield	Est. per Acre
Blarina	1	3	17	10	13	227	2	3	34	6	9	152	1	1	17	2	8	170
Peromyscus	1	1	17	0	0	0	2	2	34	0	0	0	3	5	51	1	2	34
Pitymys	0	1	0	2	2	34	0	0	0	0	0	0	0	2	0	0	0	0
Parascalops	0	0	0	0	3	51	0	0	0	1	2	34	0	1**	17**	0	0	0
Sorex fumeus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

*1937 trapping done by Drs. S. C. Kendeigh and R. A. Huggins.

**Based on the record of workings of one animal.

the ground inside the metal units to an extent unapproached outside the quadrat, form networks of runways three or four layers deep, and thereby greatly increase the foraging terrain not only for *Blarina*, but for soil invertebrates as well.

I believe that what was said about center-quadrats will also apply to the metal quadrats — namely, that estimates for a large area should certainly be based on several of them and not on just one. In this case the expense of the metal, the manual labor involved, and the length of time it takes for the quadrat to become repopulated after the initial installation of the sheeting, renders the method impracticable. If, as seems to be the case, the insulated quadrats trap certain species and thereby create unusually favorable soil conditions for still others, the insulated quadrat method would appear to be the most inaccurate source of information on populations, giving a faulty picture of not only the actual, but also the relative abundance of the species of any given small mammal fauna.

THE 100-FOOT QUADRAT, 0.229 ACRE

By the end of the summer of 1938 a total of seventy-eight 150-foot quadrats had been operated since the beginning of the work. In the course of all this a fundamental practical weakness in this size of quadrat was made clearly evident: the 150-foot quadrat must be set by at least two men. One man cannot properly set one of these quadrats in the eastern United States in less than a full day's time; and a serious error appears in the data if he takes this long. If he sets half of a quadrat in the morning and the other half in the afternoon, he will have caught several animals, under normal circumstances, before the quadrat is completely set. If, as is customary, the first day's yield is considered to be that of the first night following trap-setting, he is "padding" his results with the yield of part of an extra day. If he counts his trap-setting day as his first, he is obviously getting little service from the part of the quadrat that he last set. In short, all of his quadrat does not work for a comparable length of time, which is not to be desired. It is impractical to try to end the trapping of the two halves of the quadrat at different times, i. e. as they were set. Consequently, no less than two men should be used to set a 150-foot unit. They can finish it in half a day. They also tend to keep the movement of the small mammals

at a minimum during trap-setting. There is usually very little activity around the trapper for a radius of 50 feet during trap-setting, and two workers virtually cover a 150-foot quadrat in this way. But even when two or three men are used, some captures will often be made during the trap-setting period.

In view of the fact that two workers are not always available, there is a definite need for a "one-man" quadrat. The 100-foot quadrat largely supplies this need. During 1938 the writer instructed one of the Museum's field-workers, Mr. Winston Jesseman, in the use of these units. Mr. Jesseman operated six of them in 1938, and two in 1939. The writer operated one in 1936 and two in 1938, all three in New England.

As might be expected, the population estimates based on the yields from these quadrats (which have to be multiplied by a factor of 4.35 in order to give figures per acre) run noticeably higher than the 150-foot estimates, and much lower than the estimates based on yields from smaller quadrats. These facts, as expressed by the line representing the average daily yield, may be observed in Fig. 2. The yields after the third day in this series of quadrats are undoubtedly lower than they would have been if a series of length comparable to that of the 150-foot units had been used.

During 1938 most of the open-field 100-foot quadrats yielded population figures for *Microtus* of over 50 per acre, which is considerably higher than the average for the year for the same species as deduced from a large series of 150-foot units. Only three times since 1933 have the larger units yielded figures higher than 50 per acre for this species. Similarly, *Peromyscus leucopus* populations appeared to be about 40 per acre in 1938 on the basis of three-day 100-foot yields as opposed to the 150-foot figures, in the same ecological environment (climax forests), of 22.2.

While the error would thus appear to be considerable, it is far smaller than that incorporated in the data of smaller quadrats, and under certain circumstances this may be compensated for by the greater ease in operation that this quadrat affords in comparison to the 150-foot unit. One man *can* operate it, but wherever it is possible, two or three men should operate a 150-foot quadrat instead. The relative efficiency of the 100-foot quadrat may be visualized in Fig. 1.

CIRCULAR UNITS

Dr. S. C. Kendeigh and his students at the University of Illinois have used half-acre units of circular outline, corresponding to the 150-foot units used by the writer. A circular area with a radius of 83.2 feet that he trapped in an Illinois oak-hickory woods in November 1938, gave populations for *Peromyscus leucopus* of 16 per acre (40 per hectare), 6 per acre for *Pitymys*, 2 for *Blarina*, and 4 for *Glaucomys*. These figures are far lower than the averages for the same species in the same year in Ohio, but well in line with some other Illinois figures at hand. Unfortunately, the writer has no data that is strictly comparable to this, but a 100-foot quadrat operated by Mr. Jesseman in a swamp forest community at Bloomington, Illinois, in the same year, gave figures of 17 per acre for *Peromyscus* and 26 per acre for *Blarina*. These are well below the Ohio figures for the same habitat as furnished by 100-foot quadrats.

Dr. Kendeigh prefers the half-acre circular unit to the 150-foot quadrat because its perimeter, and hence its edge-exposure to drift, is 67 feet less and its area exactly a half-acre. The fact that this museum's youthful assistants invariably prefer to trap in the corner 50-foot quadrats of each grid, and that the corner quadrats show consistently higher yields than the others after the second day of trapping, indicates that Dr. Kendeigh's preference is very well founded. However, the difference in the yield-behavior of the various parts of a 150-foot quadrat only becomes evident after the initial three-day period is nearly over. If the three-day limit is adopted, there is no apparent difference in the yields of the two types of trapping areas in the comparative data so far accumulated by the writer (in 1939, three circular units operated, two at Aurora Pond, Ohio, one at the Holden Arboretum). However, there is no doubt that the half-acre circular unit is preferable, where it can be practically operated.

In open fields the laying out of a circular unit is an easy matter — far easier than laying out a grid or an unsubdivided 150-foot quadrat. In thorn scrub it may take ten times as long as to run the grid. The writer believes that the circular unit should be used wherever a worker can describe a perfect circle about a central point and at the same time lay a trail of string behind him. Where

this cannot be done, the circular unit can still be established by running at least four cross-lines outwards from the center, but the inaccuracy of the circle thus described vitiates wholly or in part the advantages of the circle over the 150-foot square unit. As the latter is almost always easier to run in forested country or in heavy brush, it should be used in most such cases.

GENERAL CONSIDERATIONS

An attempt to apply Raunkaier's Law of Frequence to the small mammal populations of northeastern Ohio upland forests appears in Table XII. The average percentage of frequence given for each species is that over a five-year period beginning in 1935. In compiling the data it was noted that the cyclical species usually changed their group classification from year to year, and that the Raunkaier formula failed to hold for each season. It will be seen, however, that the averaged figures closely approximate the Raunkaier formula, and seem to indicate that the law holds good among mammals as well as plants and invertebrates. Close inspection of the data reveals that the one species falling in Group D (60-80%) is *Blarina brevicauda* and that a gain of but 2/10 of a point would cause its classification in Group E. This would make the figures even more similar to the Raunkaier formula. Similarly, a gain of one point would take *Tamias* from Group A into Group B. It will also be seen that at least four of the species in Group A (*Synaptomys*, *Microtus*, *Mus*, and *Zapus*) are not strictly animals of the upland forest and are not represented by any more than one or two specimens per season; if these are deleted, the forest frequences conform still more strictly.

Fifty-foot quadrats (in all cases components of grids) are used here instead of the larger units, as the problem at hand is the relative rather than the actual abundance, and small quadrats seem to be as useful as the large. Actually, a 150-foot unit almost invariably is large enough to include most if not all of the small mammal species of an Ohio woodland. Thus, the smaller quadrat seems actually preferable to the larger for the purpose of testing the Raunkaier formula.

It is of interest to note that in Table XII we see a recapitulation

of the periodic population maxima that we found in the other tables. In this case, however, we are dealing with the distribution of the species rather than population density. In general, it would seem that widespread dispersal goes hand in hand with high density of population. That the former may sometimes occur before the attainment of the latter is indicated by the figures for *Peromyscus leucopus*. Thus, the frequence of this species was almost as high in 1937 as in the ensuing peak year 1938; but if we turn to Table XIV, we find that the 1937 populations were not nearly so great as those of 1938.

It is often asked whether the use of quadrats in counting motile organisms is justifiable. The method was originally devised for counting stationary living things like plants. The only way in which an animal such as a small mammal may be considered stationary is to think of it in terms of its "home range" in the sense suggested by Seton (1909). Insofar as its home range is concerned small mammals may be considered as fixed organisms, at least during the breeding period, if not during most of the year. If a quadrat is used that is large enough to include several home ranges, we are obviously removing "units", in a sense fixed units, in the course of trapping, and we can get a close approximation to the actual number of individuals in the area. It is equally obvious that if a small enough quadrat is used we are dealing with a part of one or more-home ranges. Eventually the animal, whose home-range includes the small quadrat, is captured, and forms part of the basis for estimating the population of a larger area than the quadrat. This population is based, however, on the yield for the small quadrat, and five animals for each 100 square meters gives a very much larger population figure per acre or hectare than one based on five animals per area ten times as great, although the larger area may more nearly approximate the actual home-ranges of the five animals than the smaller area. The accompanying graph, Fig. 1, shows quadrats of different sizes yielding the same number of animals apiece, and how the estimate per large area, based on this yield, increases as the size of the quadrat decreases. The time element is here considered constant for all sizes of quadrats.

From the above, it is evident that the smaller the quadrat, the larger is its yield in proportion to its area. Figures obtained in the

TABLE XII. Climax Forest Percentages of Frequence of Small Mammals in the Cleveland Region, 1935-1939, and their Distribution into Groups according to Raunkaier's Law. Figures give Frequences derived from Records of Approximately one hundred 50-Foot Quadrats (Components of Grids) in Each Year.

YEAR	Blarina	Sorex fumeus	Sorex cinereus	Parascalops	Condylura	Tamias	Glaucomys	Sciurus huds.	Sciurus car.	Peromyscus leuc.	Pitymys	Synaptomys	Microtus	Mus	Zapus	Napaeozapus	Sylvilagus
1935	92.6	25.9	....	11.1	....	46.4	31.4	22.2	1.8	90.7	31.4	....	....	1.8	....	....	....
1936	77.7	24.0	1.8	35.1	5.6	27.8	3.7	11.1	....	16.6	3.7	....	1.8	....	....	3.7	1.8
1937	82.2	33.3	4.4	28.8	6.7	6.7	6.7	....	....	64.4	2.2	....	....	2.2	2.2	11.0	....
1938	81.8	28.6	0.7	5.6	1.4	7.7	9.1	0.7	....	70.6	14.0	0.7	1.4	1.4	....	....	....
1939	64.8	42.5	0.9	31.4	1.8	7.3	0.9	....	....	20.3	6.4	....	....	1.8	0.9	2.7	0.9
Average, All Years..	79.8	30.8	1.5	22.4	3.1	19.1	10.3	6.8	0.3	52.5	11.5	0.1	0.6	1.4	0.6	3.4	0.5

Frequence	A	B	C	D	E
Percentage Groups	0–20%	20–40%	40–60%	60–80%	80–100%
Number of Climax Forest Frequences, per group	13	2	1	1	0
Ratio of Frequence Dispersion, According to Raunkaier's Law	5	2	1	0	1

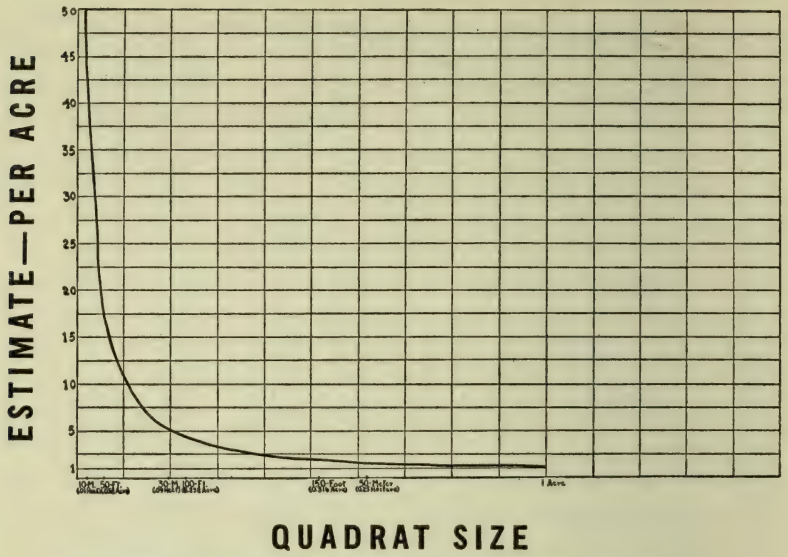

FIG. 1. Estimate-per-acre Plotted Against Quadrat Size, Yield Constant (1 animal per quadrat).

field bear out this theorem, particularly when estimates are based on total yield rather than on a limited yield after two or three days. Figure 1 indicates that there is an enormous error in estimates based on the yield from single 50-foot quadrats as compared to the "large" quadrats of 150 feet. For instance, a yield of five animals for a 50-foot quadrat gives a population of 87 per acre; for a 150-foot unit, between 9 and 10; while a yield of five per 10-meter unit gives over 200 per acre! Actually, however, it is not meant to imply that other things being equal a small quadrat will give the same yield as a large area. Over a long period of trapping, the yield of a small quadrat is to the yield of a large one more nearly as the sum of the lengths of the sides of the small one are to the sides of the large, rather than as the area of the small is to the area of the large (Table XIII). The longer the traps are kept in operation the truer this becomes, as indrifting animals which enter by the four sides of the quadrat, become a larger and larger percentage of the total. Drift is never entirely eliminated in an open quadrat unprotected by a shelter-belt of some sort, but in proportion to the "resident" popu-

lation, it becomes larger and larger as the area of the quadrat is made smaller, since the length of the perimeter of the quadrat decreases more slowly than the area enclosed. In using "total yields" with small quadrats, we are therefore confronted with two errors, the one arising from drift which cannot be legitimately considered part of the resident population, and the other from the fact that this error is greatly enlarged when it is a component of the figure per quadrat area used in estimating the population of a much larger unit.

The full import of drift in a small quadrat, even when the yield for a single night is considered, may be made obvious by the concept of a stump in the central quadrat of a grid of nine 50-foot units. Let this be theoretically the home of five deer mice (*Peromyscus*

TABLE XIII. Drift Rates of 10-Meter and 150-Foot Quadrats Compared to Each Other and to Certain Basic Quadrat Relationships.

A.	Sum of the Length of the Sides of a 10-Meter Quadrat	131.4 Ft.
B.	Sum of the Lengths of the Sides of a 150-Foot Quadrat	600.0 Ft.
C.	Ratio of A to B	1:4.565
D.	Ratio of the Area of a 10-Meter Quadrat (1076.3 Sq. Ft.) to that of a 150-Foot Quadrat (22,500 Sq. Ft.)	1:20.905
E.	Average Daily Yield per Quadrat from four 10-Meter Quadrats from the 4th to the 9th Day of trapping in 1935	1.2
F.	Average Daily Yield per Quadrat from six 150-Foot Quadrats from the 4th to the 9th Day of Trapping in 1935	5.8
G.	Ratio of E to F	1:4.83
H.	Average Daily Yield per Quadrat from four 10-Meter Quadrats from the 4th to the 7th Day of Trapping in 1936	0.25
I.	Average Daily Yield per Quadrat from twenty-three 150-Foot Quadrats from the 4th to the 7th Day of Trapping in 1936	2.19
J.	Ratio of H to I	1:8.76
K.	Ratio if the Yields During the First Six Days instead of the Last Six are used in Computing the Daily Average per Quadrat of the 10-Meter Series, 1935	1:404
L.	Ratio if the Yields During the First Four Days are used instead of Those During the last Four in Computing the Daily Average per Quadrat of the 10-Meter Series, 1936	1:4.38

leucopus noveboracensis). Let us consider that traps are set in only one 50-foot corner quadrat, and that the large quadrat constitutes the major part of the home range of the colony.* Eventually all five will wander into the corner quadrat and will be captured. This may happen in the first night and experience has shown that this is usually the case with this species in favorable weather. If, on the other hand, traps are spread over all of the nine quadrats, the chances are greatly in favor of the five being caught elsewhere in the large quadrat, perhaps one animal in each of five of the nine. Whatever the arrangement, we now have five animals caught in approximately half an acre, while in the case of the corner quadrat we have five animals caught in only 1/17 of an acre. If there are two flying squirrels (*Glaucomys volans volans*) in the district, they are as apt to be caught in the 50-foot unit, if it alone is trapped, as in the larger one if traps are set over the whole area. But the interpretation of the yield would be quite different.

Chitty (1937, pp. 50-52) emphasizes the fact that not all small mammal species are equally wide-ranging or sedentary in their habits, and that a trapline or quadrat may draw some species from a much larger area than it does others in the same length of time. It is all the more important, therefore, to use large quadrats from which the resident population can be removed at once through the medium of a large number of traps. Unless the traps are numerous enough to cut all channels of movement within the area trapped, the resident population may not be removed before the yields become seriously enlarged through drift, and this drift may consist largely of active, widely-ranging species. The impression is then made that these species are relatively more numerous in the habitat than is actually the case. Obviously, population estimates based on total yields are subject to an error from this source in addition to the others already mentioned.

The determination of the exact time after which the yield from a quadrat can be said to be of drift only is still a matter of some conjecture, but evidence is presented on the following pages in support of an arbitrary three-day limit. Until the entire small mammal

* Murie and Murie (1931, pp. 207-8) indicate that the home-range of *Peromyscus maniculatus artemisiae*, a related form, is in the vicinity of 100-yards in diameter.

fauna of a given area is rounded up with live-traps, marked, set free, and then recaptured and the details of their movements carefully noted, the problem is not likely to be satisfactorily solved. A host of American, English and Russian workers are at present engaged in research that has already added much to our knowledge of the problem. Certain species, however, are difficult to capture in live-traps, notably, among the species considered in this report, the insectivores and the lemming *Synaptomys cooperi stonei*.

It is the consensus of opinion among most mammalogists that for most cases the great majority of mammals on a trapline are removed in three nights. Townsend (1935), Hamilton (1937), and Dice (1938), used three-day limits. Elton, et al. (1935) based the estimates for their quadrats on a four-day yield. The writer feels that if large quadrats and a sufficiently large number of traps are used, the four-day limit is much too long.

The accompanying figures (Nos. 2 and 3) are indicative of the fact that there is usually a sharp decline in the daily total of captures until the third day of trapping, after which the rate of decline is much more gradual. It will also be seen that the general level of the line for any given year as compared to those of other years is an indication of the "population pressure" during that year, as evidenced by the rate of drift. A similarity in the rate of decline from year to year may also be noted, although the rate for 1933 (Fig. 3) is irregular and resembles that of the smaller quadrats (Fig. 2). Had a larger number of quadrats been used there is every likelihood that the irregularities would have disappeared. The peak occurrence on the fourth day of the 1938 trapping is an irregularity that must for the moment remain unexplained, as a large number of the 1938 quadrats contributed to the peak, and it cannot be explained on the basis of too few quadrats having been used or on any single atmospheric condition. In the average line for all five years such peaks vanish. The similarity of decline, emphasized in the average line, indicates a more or less constantly decreasing rate of drift, although the zero rate is probably never attained if a sufficient number of units are used. We may call this rate of decline after the third day "drift curve" and we note at once that in the absence of a well marked initial peak in the case of the 10-meter units (Fig. 2), the entire series of early yields seem to resemble a

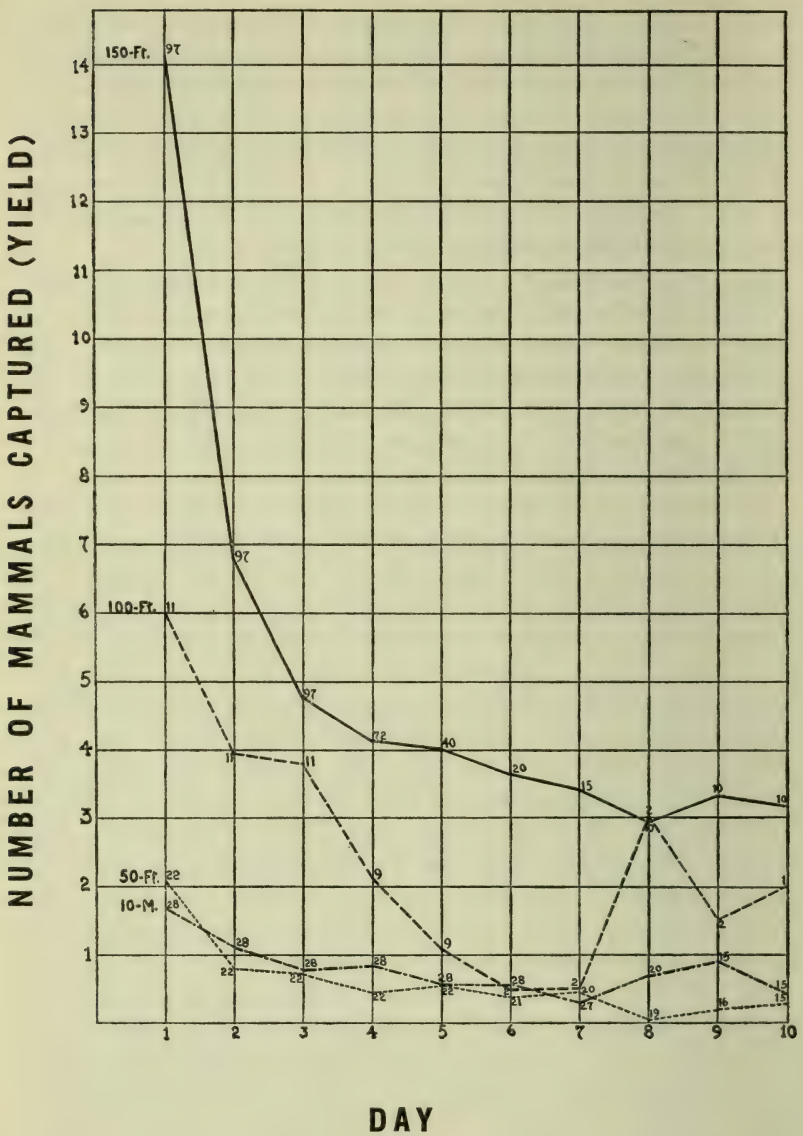

Fig. 2. Average Daily Yields of Small Mammals from Four Different Sizes of Quadrats Operated from 1932-39, Inclusive. At each point are figures giving the number of quadrats in the Average.

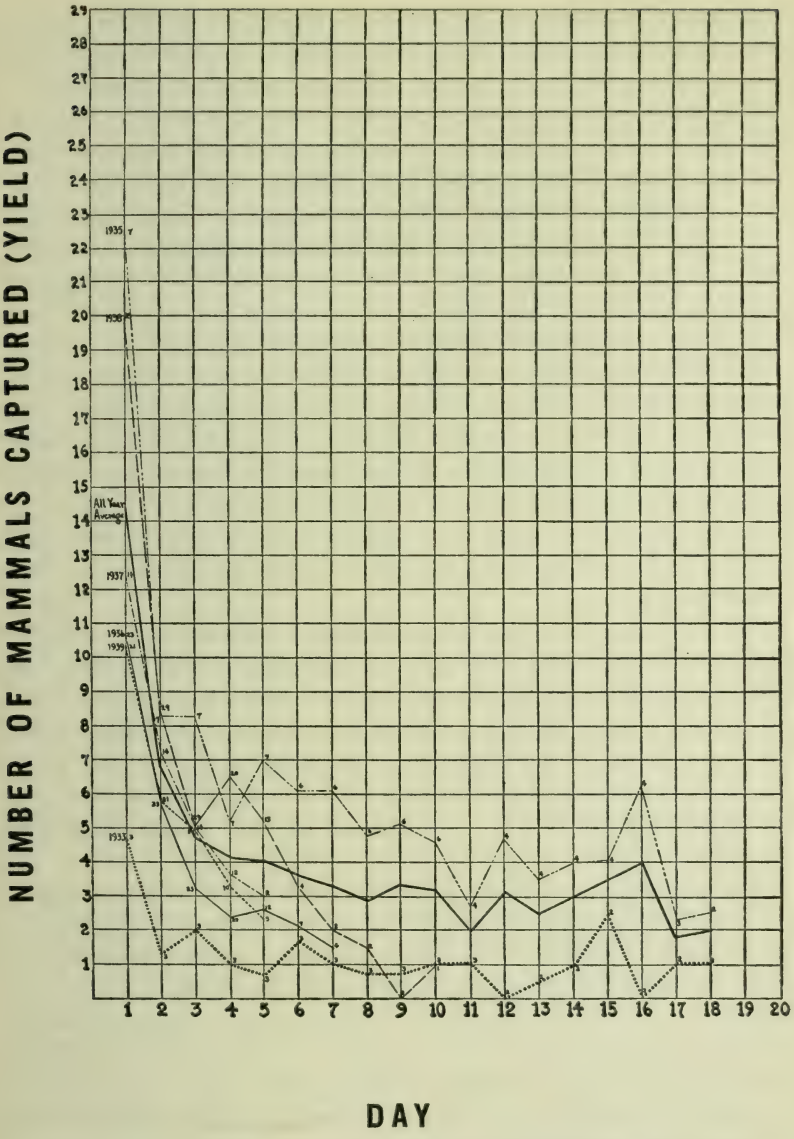

Fig. 3. Average Daily Yields from 150-Foot Quadrats in Six Different Years, with the Average Daily Yield per Quadrat for All Years. At each Point are numbers giving the number of quadrats in the Average at that point.

drift curve. On theoretical grounds, it is legitimate to assume that a 10-meter quadrat's yield would consist largely of drift owing to its small area, and the nature of the drift curves seems to support this. Further support is provided by the last item of Table XIII, where a substitution of data obtained on the first six days of trapping with 10-meter quadrats, for the data obtained from the fourth to ninth days (last six days) actually makes the ratio of the small and large quadrat yields more nearly as 1:4.5. This ratio, mentioned in Table XIII, can obviously hold only if there is some drift, i. e., a regular rate of influx. If populations are so low in any given locality that there is virtually no drift, as was the case at North Chagrin in ebb-cycle years (1933, 1936, 1939), the ratio breaks down. The weakness of the data given in Table XIII lies in the fact that all of the 10-meter quadrats were operated at but one place, whereas the 150-foot series covered a large number of localities and hence more nearly represent an average set of data. Had more 10-meter units been used, it would doubtless have become apparent that even with this size of quadrat the drift figure of zero would never be reached, and the ratio would hold.

While it may seem possible that all the residents of a quadrat might not be captured until after a three-day period, it must be remembered that some drift is occurring from the onset of trapping, and that in all probability this more than compensates for the residents uncaptured at the close of the three-day period (cf the data obtained from insulated quadrats, p. 53, Table XII). Whether this is true or not depends largely upon the thoroughness with which the quadrat is trapped.

In compiling the averages from the daily yields of the various quadrats, it became quite apparent that weather conditions greatly influence the wandering of insectivores, particularly shrews, and that a cool, humid night preceding or following rainy weather caused a marked increase in the rate of drift of these animals, while unusually hot and dry nights caused a sharp decline. Since *Blarina* is the most abundant of Ohio's mammals in nearly all habitats, it is obvious that for any one quadrat rather spectacular peaks may occur in the daily records far beyond the three-day limit, although in normal years these do not usually reach the proportions of the third or second-day yields. The sixth day peak in the 1933 record was caused

by a cool humid night preceding a light rain in the case of two of the three quadrats comprising the record, and was made up of a sudden yield of *Blarina* and *Sorex fumeus*. Where large numbers of quadrats are used, however, these peaks are usually leveled off and become lost, although in 1938 a well-marked peak occurred on the fourth day (See Fig. 3). Even here, however, the "peak" figures are inconsequential in comparison to the enormous first-day yield, and the peak disappears in the line representing the average daily yields over a six-year period.

Admittedly the selection of a three-day limit as a standard, as is done in this paper, is somewhat arbitrary. All that can be said is that the characteristic drift curve becomes pronounced either at or before the third-day, and rarely if ever after it, and that for this reason even a two-day limit seems to be more accurate than the four-day one used by Elton, at least for all the districts in which the writer has trapped. It might be added that 150-foot quadrats used in California in 1934 and in Maine in 1936 supported the data here to be given. The western quadrats will be treated in another paper.

Truly accurate data on the length of time necessary to trap the entire resident population of an area can admittedly be obtained only by the long use of quadrats thoroughly insulated from drift. The anomalous character of the results of preliminary experiments with insulated quadrats has already been indicated.

Dice (1938, p. 126) states that it is unnecessary to kill the animals taken in the course of quadrat research. The writer will be unable to agree with this statement until some satisfactory method is devised for the taking alive of shrews and moles, which often comprise nearly two-thirds of the small mammal population in Ohio. Live-trapping for *Blarina*, *Parascalops*, and *Condylura* is as yet an unfathomed problem, to the writer's knowledge, and if accurate data are required on a small mammal fauna these species must be taken.

How close together may two quadrats be placed? The answer is that in open fields they may be placed at least as close as their own diameters. Three quadrats were operated on the Holden Arboretum in 1938 along the hawthorn-covered banks of a shallow ravine. These were placed in a row up the draw, the second but 50 feet from

the first, and the third about 150 feet from the second. All three gave yields of all species normal for the habitat. There was not the slightest evidence of there having been any drainage of mammals from one to another; in fact, the first quadrat, somewhat less favorable for mammals, gave smaller initial figures than the second and third. *Synaptomys* appeared in the second but not the first or third. *Sorex cinereus* and *Mus* appeared in the third only, and *S. fumeus* in the first and third, but not the second. *Peromyscus leucopus*, *Microtus*, *Zapus*, *Condylura*, *Parascalops*, and *Blarina* were taken in all three. It might be added that in these quadrats trapping was initiated in sequence, and that the first was operated throughout the trapping period of the second and third, and the second through that of the third, which was run for four days only.

In forest habitats quadrats should undoubtedly be placed farther apart than this. A 50-foot quadrat placed about 200 feet from a grid operated at the Baldwin Bird Research Laboratory in 1935 gave every evidence of having been seriously affected. However, trapping in the smaller unit was not initiated until the grid had been trapped for six days. Three hundred yards is a safe distance; no disturbances in the yields have been noted where the quadrats have been this far apart.

The simplicity of operating break-back traps, as compared to live-traps, and the simplification of the resultant record-keeping are points in favor of the present method. There are also a number of other practical points that recommend the quadrat system. For one, a 150-foot quadrat is an excellent de-mouser for areas somewhat larger than itself, and is a useful instrument for rodent-control under certain conditions. Furthermore, there is no other way in which examples of rare species in a fauna may be so readily secured. In ordinary trapping, long trap-lines, no matter how long, usually exhaust the more abundant species before the more desirable forms are taken. This often takes several days. A 150-foot quadrat, if properly set, yields its *Napaeozapus*, *Synaptomys*, and rarer shrews on the first night, along with the usual flood of *Blarina* or *Microtus*. The taxonomist who is trying to build up a collection or who needs series of certain rare species would do well to use the quadrat method to the exclusion of ordinary trap-lines. For many years Ohio naturalists have pronounced the species of *Sorex*, *Pitymys*, and *Synaptomys*,

rare and local; the quadrat method reveals that these forms are generally distributed and locally abundant.

The reader has already been referred to the work of Townsend (1935) with regard to the bait preferences of certain small mammals. On theoretical grounds it would seem that the use of bait should very definitely increase the rate of drift at least for certain species. With this in mind, two quadrats were operated in 1939 without any bait whatever. No differences could be noted in the yields of baited and unbaited quadrats, although the test was scarcely a fair one for *Peromyscus leucopus*, which in 1939 was very low in numbers anyway. During the last six years very few of the quadrats were baited during wet weather. Another objection has been noted in the course of baiting: it attracts insects to the traps, and hence shrews; and attracts larger mammals also, — foxes, raccoons, opossums, and fox squirrels, which snap the traps and break into covered mole sets. This was found to be a serious source of trouble in 1932 when meat baits were regularly used. Since that time rolled oats have been the standard bait used by the writer and his assistants for all mouse traps; and dried fruits for the rat traps used for chipmunks, red squirrels, and flying squirrels.

Nearly all of the work heretofore reported was carried on in climax forests of different types. During 1936, 1937, 1938, and 1939, a large amount of data was obtained on the populations of many species of small mammals in a large number of different habitats. It seems unnecessary to record in detail the support given to the conclusions deduced from the work in earlier years. Suffice it to say that the following facts remain clear: (1) that the 150-foot quadrat is far better to use than any smaller size, unless but one trapper is available, in which case the 100-foot unit should be used; (2) that the basing of estimates on center quadrats of grids is faulty due to the difficulty of getting figures from a sufficiently large number of units, and that in consequence it is both unnecessary and undesirable to subdivide acre or half-acre quadrats into grids of smaller ones except as it may facilitate mapping or trap-setting; (3) that estimates of populations for any habitat should be based on more than one half-acre quadrat wherever possible; (4) that *all* parts of the quadrat must be of similar ecological constitution; (5) that the three-day limit is under most conditions the proper time allowance

and (6) that violent rain storms and severe drought may alter conditions sufficiently to make a longer time allowance desirable. In general, census-taking should be avoided during excessively dry weather. If a heavy thunder-storm snaps most of a quadrat's traps before the third day, the work should be done over in a new place.

POPULATIONS

From time to time in recent years there have appeared figures on the populations of small mammals indicating that certain species. may run as high as 100 individuals to the acre, or very much higher. Williams (1936) published figures on *Blarina brevicauda* and *Peromyscus leucopus* of over 200 per acre at North Chagrin Metropolitan Park in Ohio, as previously discussed in this report. Townsend (1935, p. 49) records 104 per acre for *Blarina;* Hamilton (1937) reports that *Microtus pennsylvanicus* attained figures of from 160 to 230 per acre during the 1935-36 mouse year in New York State; Elton, Davis, and Findlay (1935) estimate densities of over 100 and less than 200 per acre for *M. agrestis* in Scotland. These figures are minimal indeed compared to some others. Hall (1927) estimates 4,000 per acre for *Microtus californicus* during a mouse plague in California, while *Mus musculus* was estimated at the colossal figure of 78,000, an all-time high for such studies. Piper (1909) gives figures of 8,000 to 11,000 per acre for *Microtus montanus* in Nevada. That such figures are not reported solely by American workers is indicated by an estimate of 6,000 per hectare for *Microtus pelliceus* in the Soviet Union [Pidoplichka, reported by Vinogradov, (1934)]. A population of mice such as 10,000 per acre means one mouse for every four square feet of ground, and it is obvious that no habitat could stand such a population except during the passing of a great migrating horde. The writer has never encountered any such populations while using 150-foot quadrats in Ohio, Maine, Massachusetts, and California. Only once during seven years of quadrat work have we found populations greater than 100 per acre for any one species. At Aurora Pond, Ohio, in 1938 *Microtus pennsylvanicus* registered a total of 118 per acre in a rich, wet meadow. This density the writer believes to have been artificial, caused by a flooding of part of the normal habitat through the raising of the pond's water-level. In

the quadrat in question a *Microtus* was captured in every other trap of the 150-foot quadrat during the three-day trapping period. It is frankly not conceivable to the writer how populations could be much denser, but this nevertheless made him more tolerant than he previously had been of some of the published figures.

A summary of the populations per acre of some Ohio small mammals follows. All the figures are based on the three-day yields of 150-foot (45-meter) quadrats (See Table XIV). The species may be treated individually. The cyclical aspects of the figures will be treated in greater detail in a forthcoming paper.

Blarina brevicauda. Short-Tailed Shrew

Blarina, the short-tailed shrew, is the most widely distributed and most abundant mammal in Ohio. Although it is locally outnumbered in hayfields by *Microtus*, and in forests by *Peromyscus leucopus* or *Sorex fumeus*, its general average is higher than for any other species. Preliminary records seem to indicate that *Blarina* is non-cyclical, although severe drought may curtail the population sharply over a period of years. Populations have run from 0 to 30 per acre in grassland habitats, with an average of 18; in forests, the average is 26 per acre, with the highest population recorded 48 per acre. During the 1933-34 drought period figures sank as low as 4 and 10 per acre in habitats that since 1935 have yielded from 20 to 40. Nothing approaching Townsend's 104 per acre (1935, p. 49) has been recorded under natural conditions.

Cryptotis parva. Old-Field Shrew

This tiny shrew is a very rare animal in northeastern Ohio, and has been taken just once inside a quadrat, in a fallow field habitat at North Chagrin Park.

Sorex fumeus. Smoky Shrew

Smoky shrew populations are very susceptible to drought, and apparently are affected by cycles as well. During the 1937-38 *Sorex* peak their numbers reached 15 per acre in upland forests, while in one instance at Little Mountain, a population of 58 per acre was recorded, one of the highest ever discovered for any species in the

course of this work. In habitats other than climax forests *Sorex fumeus* is distinctly uncommon, the average being less than 1 per acre.

Sorex cinereus. Canada Shrew

The transitory characteristics of Ohio *Sorex cinereus* populations afford special problems in determining peaks and population figures. During favorable (i. e., cool, wet) years, this species is found chiefly in old fields and on fallow land; during droughts the species retires to sedge meadows, cat-tail marshes and swamp forests. Such migrations may occur several times in one year. Where suitable dry-weather habitats are lacking, *Sorex cinereus* does not occur in Ohio. Figures available indicate that the species was at peak in 1937 with populations of from 1 to 11 per acre. High figures (5 per acre) in fields during 1938 were caused by excessively high water-levels in bogs and marshes generally. During other years the population is usually much lower than 1 per acre.

Parascalops breweri. Hairy-Tailed Mole

The hairy-tailed mole is one of the most important forest mammals in Ohio from an ecological standpoint. Its numbers were at a great peak in 1936 during which populations of as high as 24 per acre were noted. The average for climax forests was 7.6, as opposed to figures of 1, 2, or 3, per acre in other years. In other habitats the population has usually been in the vicinity of 1 or 2 per acre. The species avoids most communities of the hydrosere except during drought years. Trapping *Parascalops* with mouse-traps, the only practicable means in quadrat work, requires a special technique of setting which is only learned through experience. The writer's limited experience with *Scalopus*, which no longer occurs in the region under consideration, indicates that the same methods will not always work with that form.

Condylura cristata. Star-Nosed Mole

Star-nosed moles offer few special problems in trapping, and a population may be easily removed with mouse traps. Although climax forests are not this species' favorite habitat, they constitute the best areas for cyclical studies. It is evident that they were at

peak in 1936, and the highest population noted, 6 per acre, was recorded in a sedge meadow during that year. Ordinarily this mole is more abundant in swamp forests than elsewhere. Its concentrations there are dependent upon water levels. During very wet years it freely invades hayfields and fallow land.

Tamias striatus. Chipmunk

The cyclical nature of seed production of beech and sugar maple seems to be the basic factor regulating the changes in chipmunk population densities. In 1935, following a year of great seed production by these trees, chipmunk populations reached a figure of 8.7 per acre in upland forests, a density that is undoubtedly exceptionally high, as similarly favorable conditions in 1937 resulted in but a very slightly higher figure (1.14 per acre) for 1938 than the lowpoint of the previous year (0.8 per acre).

Sciurus hudsonicus. Red Squirrel

Red squirrel populations in Ohio were at their highest in 1935 (1.7 per acre), since which time they have steadily dwindled to a point where they no longer figure in quadrat records, a truly remarkable decline. Careful counts made at Little Mountain over a period of years corroborate the results obtained with the quadrats.

Glaucomys volans. Flying Squirrel

Like the other herbivorous species treated in this paper, flying squirrels were at peak in 1935, when populations were generally in the vicinity of 3 per acre in woodland habitats. A sharp drop to 0.4 occurred in 1936, since which time there has been a slow recovery. The largest population ever noted was one of 6 per acre during the late summer of 1938, in a beech-maple forest. During this year a low peak was registered. In 1939 the species suffered a virtual eclipse, the writer's field assistants having been unable to supply the Cleveland Museum's Preparation Department with enough specimens for a small habitat group.

Peromyscus leucopus. Deer Mouse

Great cyclical disturbances occur in the deer mouse populations of any Ohio woodland, but the numbers of this ordinarily abundant

mammal apparently do not approach the figures reported by other workers for other localities. A density of 46 per acre, recorded in 1938 in an isolated beech-maple woodland, was the greatest noted. Average figures for all upland forest habitats were 29 per acre during the 1935 peak. In 1936, during the ebb of the cycle, *Peromyscus* became positively uncommon, 5.2 per acre, a figure below that of *Sorex fumeus* and *Parascalops breweri* for the same year. Recovery progressed steadily after 1936 and an average figure of 22.2 per acre was attained by the summer of 1938. Staple food crop failures during this year curtailed the trend, however, and the figure of 22.2 in 1938 marks another maximum which completes a second three-year interval between peaks. During 1939 *Peromyscus* virtually vanished from Ohio's forests.

In other habitats deer mice come and go, depending on conditions within the upland forests. Populations are rarely as great as they are there. In general thorn-apple scrub and fallow fields are not inhabited unless populations are nearly at peak in the forests. Swamps and bogs show fluctuations corresponding to changing water-levels, and in open country, far from scrub or woodland, this species is replaced by the next, *P. maniculatus bairdi*.

A curious population of 38 per acre was noted in a flood-plain woodland along the Rocky River west of Cleveland in 1936. This was more than twice as great a population as was noted in any other habitat during that year, was more than six times as great as any population at any other station, and was all the more remarkable in that the habitat is periodically under from one to three feet of fast-moving water each winter. In general it may be said that the herbivorous species of small mammals were all at figures reminiscent of the 1935 peak at Rocky River, where for some reason, to date undiscovered, the factors tending to liquidate the 1935 peak were not effective.

Peromyscus maniculatus. White-Footed Mouse

Prairie white-footed mice are rare and local in northeastern Ohio, except on the beaches and sand-dunes along the shore of Lake Erie. Here, in 1935 transect trap-line records used in conjunction with a 50-foot quadrat indicated that a 150-foot quadrat might have yielded very high figures. By 1936, when the first large quadrat was

used, populations were still at 22 per acre, although far less numerous than in the previous year. The habitat has not been trapped since. Elsewhere, the highest population noted is 4 per acre, with the average for fallow fields of 1.5 in 1938, 0.7 in 1937, and no records whatever in 1936. These fragmentary records suggest that 1935 and 1938 both marked peak years for this form, as for other herbivorous species.

Microtus pennsylvanicus. Field Vole

As usual elsewhere with most workers, it is a species of *Microtus* that holds our Ohio records for the greatest number of individuals per acre, as noted previously. Figures of 118 per acre in a rich meadow in 1938 constitute an all-time high. A second quadrat nearby reduced the average for that particular habitat to 85 per acre, which is still higher than any recorded elsewhere. The species was at peak in 1929, 1932, 1935, and again in 1938, although there were no factors now apparent that should have tended to keep the populations from further increasing in 1939. Actually, sharp decreases were noted in 1939. The 1935 peak was by far the greatest.

Microtus is generally distributed in all habitats in which herbaceous vegetation is continuously abundant throughout the year. Populations often show great numerical variations in any given year, but the general tendency has been strongly cyclical in all habitats save those in which water levels have caused migrations of seasonal character. The 1936 figure of 28.3 per acre in fallow fields is far higher than it should be as it includes in its record but three quadrats and one was in a field at Rocky River, already alluded to, in which a single quadrat yielded a figure of 76 per acre.

Pitymys pinetorum. Pine Vole

Pine voles are forest-edge animals in Northern Ohio. During cyclical maxima they spread inwards into the forests and are then to be found throughout the larger woodlands in the Cleveland region. The North Chagrin Park figure of 18 per acre (1935) is by far the highest ever recorded by means of quadrats, and brought the average figure for that year to 6.4 as compared to the ebb-cycle figure of 0.5 per acre in 1937. The 1938 record shows that *Pitymys* was again at peak.

Synaptomys cooperi. Lemming Vole

Ohio's only lemming is generally distributed but not at all common. The somewhat meager evidence available from small quadrat and trapline sources indicates that a very high peak occurred in 1935, when the species was first reported for the region under consideration. Just how great the populations were at that time is somewhat of a mystery as but one quadrat was operated in a habitat suitable to this species. This gave a figure of 4 per acre. The highest figure obtained since 1935 is one of 6 per acre at the Holden Arboretum in July, 1938. The average for this year, 1.5, is no higher than that for 1937. That the species was at peak seems to be indicated by the fact that it appeared in a greater variety of habitats in 1938 than in earlier years, although the figures in every case are very low.

Zapus hudsonius. Hudson-Bay Jumping Mouse

Up to the present time (1939) the figures obtained through the use of quadrats have failed to indicate the existence of a well-marked cycle in the population-changes of this jumping mouse. The highest figures recorded for this species are 18 per acre in a rich meadow and 12 per acre in a swamp shrub (*Alnus-Cephalanthus* associes) community. Both figures were obtained in 1936. In fallow fields the maximum figure of 3.5 per acre was recorded in 1939, while in brushy scrub (*Rhus-Crataegus* associes) the maximum was obtained in 1938. Such figures indicate plainly that *Zapus*, like *Sorex cinereus* and *Microtus*, is greatly influenced by local and seasonal variations of water levels, relative humidity and general precipitation as reflected by lushness of herbaceous vegetation. *Zapus* is not a regular inhabitant of upland forests, the most stable of Ohio habitats, and in consequence cyclical records will be difficult to secure. That cyclical maxima do occur is very probable, in view of the periodic outbreaks of this species in Ohio hayfields. It has not yet been the fortune of the writer to be able to work in such a locality.

Napaeozapus insignis. Woodland Jumping Mouse

Trapping has been continued long enough in the case of the woodland jumping mouse to establish the existence of a cycle, but

the length of it has not been determined. The records are very much less numerous than for *Zapus*, but as this species inhabits upland forests, they are relatively little affected by water-table and climatic factors. A peak occurred in 1937, when populations reached a figure of 2.8 per acre, while an ebb apparently occurred in 1934 and 1935, when the species was not taken in any quadrat. The highest figure noted is one of 10 per acre at Shady Lake, Ohio, in a bog forest (*Acer-Betula* associes) in 1938. This is the first and only time the species has been taken in this habitat.

Mus musculus. House Mouse

House mouse records are scattered and irregular and show no convincing evidence of peaks or other manifestations of cyclical phenomena. A population of 4 per acre in a sedge meadow habitat is the largest yet on record for their species in Ohio.

Other species

Besides the forms listed above, other species are occasionally taken inside quadrats. In all cases these are larger mammals, and the irregularity of their capture is in line with their very apparent low density of population as compared to the smaller forms. The Northern gray squirrel (*Sciurus carolinensis leucotis*) and the cottontail rabbit (*Sylvilagus floridanus mearnsi*) are occasionally captured in the rat-traps set for chipmunks and flying squirrels, and at least once during our work with quadrats of different sizes each of the following have been taken: the skunk (*Mephitis nigra*), Virginia opossum (*Didelphis virginiana*), least weasel (*Mustela rixosa*) and Norway rat (*Rattus norvegicus*). The quadrat method is not effective with these larger species, since there is a great disparity in size between the quadrat and the home range of the animal.

Only four of the terrestrial small mammals known to occur in northeastern Ohio have so far eluded capture in the quadrats. One of these is the New York weasel (*Mustela frenata noveboracensis*) and two, the Red-backed vole (*Clethrionomys gapperi*) and Common mole (*Scalopus aquaticus*) are probably extinct today; the last is a very rare shrew (*Microsorex hoyi thompsoni*). The fact that these species have not been taken is evidence of their relatively great rarity.

TABLE XIV. Small Mammal Populations in the Cleveland, Ohio Region, 1935-39. Figures give the number per acre and are the averages of estimates based on the yields of single 150-foot quadrats.

Habitat and Year	Blarina brevicauda	Sorex fumeus	Sorex cinereus	Cryptotis parva	Parascalops breweri	Condylura cristata	Tamias striatus	Glaucomys volans	Sciurus hudsonicus	Peromyscus leucopus	Peromyscus maniculatus	Microtus pennsylvanicus	Pitymys pinetorum	Synaptomys cooperi	Zapus hudsonius	Napaeozapus insignis	Mus musculus	Sylvilagus floridanus	Number of Quadrats in Average
CLIMAX FORESTS																			
1935	25.7	3.7	....	....	2.0	....	8.7	3.3	1.7	29.0	....	....	6.3	....	....	....	....	....	6
1936	23.6	8.0	0.4	....	7.6	0.8	2.8	0.4	0.8	5.2	....	....	1.2	....	....	0.4	....	....	5
1937	29.7	15.5	1.0	....	3.5	0.5	0.8	1.2	0.5	14.0	....	....	0.5	....	....	2.8	....	....	4
1938	34.2	9.7	0.1	....	1.1	0.3	1.1	1.6	0.1	22.2	....	0.3	2.9	....	0.1	1.6	....	....	14
1939	22.9	13.1	0.2	....	5.5	0.4	1.5	0.2	....	3.6	....	....	1.5	....	....	0.7	0.4	0.2	11
BOG FORESTS																			
1936	5.0	0.5	3.0	....	1.5	1.5	0.5	0.5	1.0	4.0	....	3.5	....	....	1.5	....	....	....	4
1937	6.0	3.0	7.0	....	....	4.0	....	3.0	1.0	24.0	....	6.0	....	....	....	....	....	....	2
1938	14.0	3.0	2.0	....	1.0	....	....	....	....	7.0	....	3.0	....	....	....	5.0	....	....	2
1939	24.0	4.0	2.0	....	....	6.0	2.0	....	....	6.0	....	26.0	....	....	....	....	....	....	1
BOG MEADOWS																			
1936	5.0	....	3.0	....	....	4.5	....	....	....	....	....	12.0	....	....	....	....	1.0	....	4
1937	12.0	1.0	2.0	....	2.0	3.0	....	....	....	1.0	....	13.0	....	....	7.0	....	4.0	....	2
1938	4.0	....	1.0	....	....	1.0	....	....	....	2.0	....	35.0	....	....	2.0	....	1.0	....	2
1939	5.0	1.0	2.0	....	....	2.0	....	....	....	....	....	36.0	....	....	....	....	1.0	....	2

TABLE XIV Cont.

Habitat and Year	Blarina brevicauda	Sorex fumeus	Sorex cinereus	Cryptotis parva	Parascalops breweri	Condylura cristata	Tamias striatus	Glaucomys volans	Sciurus hudsonicus	Peromyscus leucopus	Peromyscus maniculatus	Microtus pennsylvanicus	Pitymys pinetorum	Synaptomys cooperi	Zapus hudsonius	Napaeozapus insignis	Mus musculus	Sylvilagus floridanus	Number of Quadrats in Average
FALLOW FIELDS																			
1936	9.3	....	....	....	0.7	....	....	....	....	....	....	29.0	....	0.7	1.3	....	0.7	....	3
1937	11.3	....	0.7	0.7	1.3	....	....	....	....	2.7	0.7	3.3	....	2.0	2.7	....	0.7	....	3
1938	28.5	....	5.0	....	2.0	1.0	....	....	....	2.5	1.5	26.5	....	1.5	0.5	....	....	....	4
1939	8.5	0.5	0.5	....	1.0	....	....	....	....	0.5	0.5	14.5	....	....	3.5	....	1.0	....	4
RICH MEADOWS																			
1936	30.0	....	....	....	2.0	....	....	....	....	2.0	....	16.0	....	....	18.0	....	....	....	1
1937	24.0	....	....	....	....	....	....	....	....	....	....	14.0	....	....	6.0	....	....	....	1
1938	13.0	....	5.0	....	....	1.0	....	....	....	3.0	....	85.0	....	1.0	2.0	....	3.0	....	2
1939	26.0	....	4.0	....	....	....	....	....	....	....	....	18.0	....	....	2.0	....	....	....	1
WOODS EDGE																			
1935	24.0	....	....	....	4.0	....	8.0	2.0	2.0	34.0	....	4.0	6.0	4.0	....	....	....	....	1
1936	16.0	....	....	....	13.0	....	3.0	....	....	....	....	3.0	....	1.0	1.0	....	....	....	2
1937	28.0	....	....	....	7.0	....	1.0	2.0	....	14.0	....	5.0	....	3.0	3.0	1.0	....	....	2
1938	24.0	....	2.0	....	4.0	....	....	....	....	10.0	....	12.0	....	....	4.0	....	4.0	....	1
1939	20.0	14.0	....	....	....	....	....	....	....	....	....	6.0	....	2.0	....	....	....	....	1
THORN SCRUB																			
1938	20.0	0.4	0.4	....	1.2	2.4	2.0	....	0.8	7.2	....	15.6	....	1.2	4.8	....	1.2	....	5
1939	6.0	....	....	....	....	....	....	....	....	2.0	....	....	....	....	2.0	....	....	....	1
FLOOD PLAIN FOREST																			
1936	22.0	....	....	....	2.0	....	....	....	2.0	38.0	....	16.0	....	....	....	....	2.0	....	1
COASTAL SAND DUNES																			
1936	....	....	....	....	....	....	....	....	....	....	22.0	4.0	....	....	....	....	....	....	1

CONCLUSIONS

From a study of the yields of small mammals obtained from several sizes of trapping quadrats over a period of eight years, it is decided that:

(1) The quadrat method provides an accurate means of determining small mammal abundances;

(2) In general, the larger the quadrat the more accurate the results, and that quadrats 150 feet or 50 meters on a side or circular units of corresponding area are still small enough to be easily operated and are large enough to provide a high degree of accuracy, and hence should be considered the standard sizes for population investigations of mammals whose home ranges are of the same size or smaller than that of the quadrat;

(3) The use of shelter-belts or outer tiers of quadrats about a central one is not justifiable because of the tremendous labor involved if the quadrat is maintained at standard size, because the belts themselves cause population disturbances within the quadrat, and because the data the belts yield can be put to better statistical use if the traps that furnished them are part of the quadrat itself;

(4) More than one quadrat should be used in any given community, but should be placed no closer to eachother in forests than 300 yards, and no closer than 100 yards in fields;

(5) All parts of a quadrat must be ecologically uniform and similar to the larger area which it is meant to represent, if figures on populations for one particular habitat are desired;

(6) A three-day trapping limit should be set, as the resident population is practically exhausted in this time;

(7) Trapping within a quadrat must be thorough and executed with the sole purpose in mind of getting all the mammals out of it as swiftly as possible, for which reason traps should be set in underground or surface runways or wherever the mammals are, and should not be set at regular intervals within the quadrat, since the lairs and runways do not so arrange themselves in nature;

(8) The use of insulated quadrats is futile as the metal sheeting used will cause spectacular changes in the ecological picture of the quadrat, particularly if moles are part of the small mammal fauna;

(9) The use of very small quadrats (smaller than 100 feet on a side) is indefensible owing to the relatively high percentage of animals drifting into them from adjacent terrain;

(10) Quadrats are found to be particularly useful in studying cyclical changes in small mammal populations and in collecting the less common species of a given small-mammal fauna.

LIST OF REFERENCES

Aldrich, J. W. (MS.) Ecology of the Swamps and Bogs of Northeastern Ohio. (Unpublished manuscript in the library of Western Reserve University).

Chitty, D. (1937, May) A Ringing Technique for Small Mammals. Jour. Animal Ecol., Vol. 6, No. 1, pp. 36-53, 5 figures.

Dice, Lee R. (1931, Nov.) Methods of Indicating the Abundance of Mammals. Jour. Mammalogy, Vol. 12, No. 4, pp. 376-381.

———— (1938, July) Some Census Methods for Mammals. Jour. Wildlife Management, Vol. 2, No. 3, pp. 119-130.

Elton, Charles (1924) Periodic Fluctuations in the Number of Animals: Their Causes and Effects. Brit. Jour. Exp. Zool. Vol. 2, pp. 119-163.

———— (1925) Plague and the Regulation of Numbers in Wild Animals. Jour. Hygiene, Vol. 24, pp. 138-163.

Elton, C.; Davis, D. H. S.; and Findlay, G. M. (1935, Nov.) An Epidemic among Voles (*Microtus agrestis*) on the Scottish Border in the Spring of 1934. Jour. Animal Ecology, Vol. 4, No. 2, pp. 277-288.

Grinnell, Joseph (1914) An Account of the Mammals and Birds of the Colorado Valley with Especial Reference to the Distributional Problems Presented. Univ. Calif. Publ. Zool. Vol. 12, pp. 51-294.

Grinnell, J. and Storer, T. I. 1924. Animal Life in the Yosemite. Berkeley. Univ. Calif. Press. 752 pp., 62 plates.

Hall, E. R. (1927) An Outbreak of House Mice in Kern County, California. Univ. Calif. Publ. Zool. Vol. 30, No. 7, pp. 189-203.

Hatfield, D. M. (1938, May) Studies on Rodent Populations of a Forested Area. Jour. Mamm. Vol. 19. No. 2, pp. 207-11, 2 fig.

Hamilton, W. J., Jr. (1937, May) The Biology of *Microtus* Cycles. Jour. Agr. Res. Vol. 54, No. 10.

Jaccard, Paul. (1912) Distribution of the Flora in the Alpine Zone. New Phytologist, Vol. 11, pp. 37-50.

Kenoyer, L. A. (1927) Raunkaier's Law of Frequence. Ecol., Vol. 8, No. 3, pp. 341-349.

MacLulich, D. A. (1937) Fluctuations in the Numbers of the Varying Hare (*Lepus americanus*). Univ. Toronto Studies, Biol. Ser., No. 43, pp. 1-136, 18 fig.

Middleton, A. D. (1930) Cycles in the Numbers of British Voles (*Microtus*). Jour. Ecol., Vol. 18, pp. 156-166.

———————— (1931) A Further Contribution to the Study of Cycles in the British Vole (*Microtus*). Jour. Ecol. Vol. 19, pp. 190-199.

Murie, O. J. and Murie, A. (1931, Aug.) Travels of *Peromyscus*. Jour. Mamm. Vol. 12, No. 3, pp. 200-209.

Phillips, J. F. V. (1931). Quantitative Methods in the Study of Numbers of Terrestrial Animals in Biotic Communities: A Review, with Suggestions. Ecol., Vol. 12. No. 4, pp. 633-649.

Piper, S. E. (1909) The Nevada Mouse Plague of 1907-8. U. S. Dep't Agr. Farmers' Bull. No. 352, 23 pp.

Pound, Roscoe and Clements, F. E. 1898. The Phytogeography of Nebraska. I, General Survey. Lincoln.

Ruhl, H. D. (1932) Methods of Determining the Abundance of Some Game Species. Trans. 19th Amer. Game Conference.

Seton, E. T. 1909. Life Histories of Northern Animals. 560 pp. C. Scribner's Sons, New York City.

Shelford, V. E. 1929. Laboratory and Field Ecology. The Responses of Animals as Indicators of Correct Working Methods. pp. 1-55. Baltimore. Williams & Wilkins Co.

Taylor, W. P. (1930) Methods of Determining Rodent Pressure on the Range. Ecol., Vol. 11, No. 3, pp. 523-542.

Thomas, E. S. and Bole, B. P., Jr. (1938, Feb.) List of the Mammals of Ohio. Ohio State Museum Mimeographed Bull. No. 1. 2 pp.

Townsend, M. T. (1936, July) Studies on Some Small Mammals of Central New York. Roosevelt Wild Life Annals, Vol. 4, No. 1.

Vinogradov, B. S. (1934) Materials for the Study of the Dynamics of the Faunas of Muriform Rodents in the U.S.S.R. (Historical Review of Fluctuations of Mice in the U.S.S.R.) 61 pp. Leningrad. (U.S.S.R. People's Commisariat Agr., Assoc. Control of Pests and Diseases, Rec. Serv.) (Text and Titles in Russian, with English summary).

Williams, A. B. (1936, July) Composition and Dynamics of a Beech-Maple Climax Community. Ecol. Mon., Vol. 6. No. 3, pp. 318-408; also Sci. Publ. Cleve. Mus. N. H., Vol. 6, pp. 1-96.

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SCIENTIFIC PUBLICATIONS
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DESCRIPTION OF A NEW HOUSE MOUSE FROM CUBA

By

Philip N. Moulthrop

In the course of the field work carried on by the 1941 Corning Cuba Expedition of The Cleveland Museum of Natural History a new and strikingly marked race of the European house mouse was discovered in the Trinidad Mountains of Cuba.

For comparative purposes it was necessary to examine critically all the *Mus musculus* material in the Cleveland Museum of Natural History collection. Remarks on the status of the house mouse in North America are included in the discussion of the new race.

Acknowledgments are due Mr. Warren H. Corning, Trustee of this museum, for making the Cuban collecting trip possible. Valuable assistance was rendered in Cuba by the staff of the Atkins Institute of the Arnold Arboretum, officials of the Soledad Sugar Company, and Dr. Luis Howell y Rivero of the Poey Museum.

Mus musculus percnonotus, subsp. nov.
Trinidad Mountain House Mouse

Type.—Adult male, skin and skull, No. 16801, Cleveland Museum of Natural History; Mina Carlota, Barrio de Cumanayagua, Trinidad Mountains, Santa Clara, Cuba (altitude 1200 ft.); April 5, 1941; P. N. Moulthrop, original number, CC-46.

Distribution and Habitat.—Known only from the type locality, but possibly ranging throughout the Trinidad Mountains. Our specimens were taken in a permanent marsh from runways in cut-grass and cattails.

General Characters.—A very dark subspecies having the wide, black dorsal band and black tail of *Mus musculus jalapae* Allen and Chapman,[1] from Jalapa, Vera Cruz, Mexico, but with a conspicuous black nose patch and a much shorter ear than found in any of the known subspecies of *Mus musculus* Linnaeus.

Color.—The type, in slightly worn pelage, has the upper parts with a dorsal band of black, faintly sprinkled with fuscous, extend-

[1]Bull. Amer. Mus. Nat. Hist., Vol. IX, Art. 13, June 16, 1897, p. 198.

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ing from temporal region to base of tail, and occupying almost one half the whole dorsal area; tail uniformly black; sides buffy brown tinged with cinnamon and well mixed with black hairs; under parts slightly paler and without black hairs; feet dusky drab; toes white; nose conspicuously black, this black patch including area at base of whiskers; cheeks and interorbital region dark buffy brown; ears blackish brown.

Skull.—Not clearly distinguishable from that of *M.m. musculus* or *M.m. brevirostris* Waterhouse[2] (=*M.m. azoricus* Schinz of some authors). On the basis of this similarity the present form should receive no more than subspecific rank in spite of the striking external differences.

Measurements.—The type and 1 subadult female (in parentheses): length, 160 mm. (141 mm.); tail, 80 (68); hind foot, 19 (17); ear, 11 (10).

Remarks.—This dark, richly colored form cannot be confused with any of the known races of house mice. The common house mouse of Cuba is probably *Mus musculus brevirostris* Waterhouse, the south European house mouse. Seven specimens collected in the field at the Atkins Institute of the Arnold Arboretum, Soledad, Cuba, are referable to this light colored, buffy form.

Harper[3] has pointed out the occurrence of the south European house mouse in North America and referred specimens from the Bahamas and the Lesser Antilles to that form, but used the name *M.m. azoricus*, which is a synonym of *Mus musculus brevirostris*. The large series of house mice in the mammal collection of the Cleveland Museum of Natural History generally bears out Harper's suggestion of a southerly distribution for the south European form in North America. However, the house mice in the New World seem to be in a state of flux, and great individual variation may be found in series from almost any locality. Some series have characters intermediate between *M.m. brevirostris* and *M.m. musculus*, while others show tendencies toward new racial distinctions. A most striking example of this differentiation occurs in a series of *Mus* from the Olympic Peninsula in Washington, which exhibits a richening of color along with an increase in size and a lengthening of rostrum, although similar in other respects to

[2]Cabrera, Trab. Mus. Nac. de Cienc. Nat. Madrid, Zool. Ser., No. 57, Dec. 30, 1932, p. 255.

[3]Journ. Mamm., Vol. XI, No. 1, Feb., 1930, pp. 49-52.

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M.m. brevirostris, the southern form. A series from Red Rock, Arizona, appears to be a 'faded' desert variant of the northern form. Another desert stock, from Owens Valley, California, is plainly derived from the southern race, but seems to be developing a lateral line of fulvous. Dice[4] noted this tendency in about half his California specimens. A small series of beach-caught specimens from northern Ohio (Richmond Beach and Bay Point) exhibits noticeable paleness and light under parts but no trace of buffy or reddish coloration. Series from Columbiana County in southeastern Ohio, Lawrence County and Adams County in southern Ohio, Randolph County, West Virginia, Posey County, Indiana, and Washington County, Nebraska, show characters which are more or less intermediate between *M.m. musculus* and *M.m. brevirostris*. This would seem to indicate an intergradation area along the Ohio River valley.

It is possible that the house mice of the New World may not represent extensions of the ranges of the European forms and may have developed the similar north-south division of pelage characteristics independently since the original introductions. Support for this contention is found in the great range of individual variation and series variation present in our specimens from localities in eastern North America, where climatic conditions are similar to those of western Europe. For the purpose of this paper, however, light or buff-bellied house mice with buffy to reddish dorsal regions are considered *M.m. brevirostris*. Similarly, our dark-bellied, dull colored house mice are here regarded as *M.m. musculus*. In separating our *brevirostris* from true *musculus* Miller's[5] descriptions were used and specimens were placed according to the appearance of the series as a whole, even though individual extremes might be more readily referred to the other race. No attempt has been made to classify our *Mus* from Arizona and the Olympic Peninsula, Washington.

There is a curious, unexplained pinkish color in the skulls of our specimens of *Mus musculus percnonotus* although they were preserved and cleaned by the same method used in preparing all our mammal skulls. A similar pinkish cast is present in most of the fox squirrel skulls in the Cleveland Museum of Natural History.

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[4]Science, N. S., Vol. XXXV, May 24, 1912, p. 835.

[5]Catalogue Mammals Western Europe, 1912, pp. 869-874.

The new house mouse from the Trinidad Mountains in Cuba is darker than any North American stock except *Mus musculus jalapae*, and is further distinguished by its short ears.

Colors used in the description of *M.m. percnonotus* are those of Ridgway.[6]

Specimens examined.[7]—

Mus musculus percnonotus

CUBA: Mina Carlota, Trinidad Mountains, Santa Clara Prov., 2 (the type and one topotype).

Mus musculus brevirostris

CAPE VERDE ISLANDS: San Nicolao, 1.
CUBA: Soledad, Santa Clara Prov., 7.
CALIFORNIA: Owens Valley, Inyo Co., 5; Owens Valley, Mono Co., 1.
OHIO: Smoky Creek, Adams Co., 14; Symmes Creek, Lawrence Co., 1.
SOUTH CAROLINA: Grays Hill, Beaufort Co., 19.
TEXAS: Corpus Christi, Nueces Co., 6.
WEST VIRGINIA: Laurel Mountain, Randolph Co., 7.

Mus musculus musculus

NOVA SCOTIA: Seal Island, Guysborough Co., 3.
ILLINOIS: Bloomington, McLean Co., 3.
INDIANA: New Harmony, Posey Co., 6.
IOWA: Tama, Tama Co., 1.
MASSACHUSETTS: Taunton, Bristol Co., 1; Essex, Essex Co., 2.
MICHIGAN: Golden Lake, Iron Co., 1; Newberry, Luce Co., 1; Waters, Otsego Co., 1.
NEBRASKA: Blair, Washington Co., 7.
NEW JERSEY: Mays Landing, Atlantic Co., 1.
NEW YORK: St. Huberts, Essex Co., 3: Wading River, Suffolk Co., 1.
OHIO: Mechanicsville, Ashtabula Co., 1; Padanaram, Ashtabula Co., 1; Cat Run, Belmont Co., 5; Lisbon, Columbiana Co., 3; Bedford, Cuyahoga Co., 2; Chagrin Falls, Cuyahoga Co., 4; Cleveland, Cuyahoga Co., 12; Cleveland Heights, Cuyahoga Co., 3; Gates Mills, Cuyahoga Co., 4; Independence, Cuyahoga Co., 1; Lakewood, Cuyahoga Co., 4; Lyndhurst, Cuyahoga Co., 7; Rocky River, Cuyahoga Co., 1; Chesterland, Geauga Co., 2; Lake Punderson, Geauga Co., 1; Little Mountain, Geauga Co., 4; Parkman, Geauga Co., 1; Fostoria, Hancock Co., 2; Holden Arboretum, Lake Co., 8; Madison Township, Lake Co., 2; Mentor, Lake Co., 6; Mentor Harbor, Lake Co., 1; Richmond Beach, Lake Co., 3; Avon Lake, Lorain Co., 1; Bay Point, Ottawa Co., 4; Payne, Paulding Co., 1; Aurora Pond, Portage Co., 10; Burgoon, Sandusky Co., 3; Bettsville, Seneca Co., 26; Cromers, Seneca Co., 3; Feaselburg, Seneca Co., 1; Liberty Township, Seneca Co., 1; Maple Grove, Seneca Co., 3; Old Fort, Seneca Co., 2; Peninsula, Summit Co., 1; Longley, Wood Co., 1.
SOUTH DAKOTA: Bull Springs, Harney Co., 2.

Mus musculus (subsp.)

ARIZONA: White Tank Mountains, Maricopa Co., 1; Hardyville, Mojave Co., 1; Red Rock, Pima Co., 5.
WASHINGTON: Forks, Clallam Co., 14.

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[6]Color Standards and Color Nomenclature, 1912 [Jan. 16, 1913], pp. [1-4]; i-iv; 1-44; frontispiece; pls. I-LIII.

[7]Localities arranged alphabetically by counties.

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THE OHIO RECENT MAMMAL COLLECTION IN THE CLEVELAND MUSEUM OF NATURAL HISTORY

By

B. Patterson Bole, Jr.

and

Philip N. Moulthrop

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ERRATA

Page 99. Footnote to be supplied, referring to **kirtlandi:**

[1]Named in honor of Dr. Jared Potter Kirtland, pioneer Ohio mammalogist, ornithologist, icthyologist, horticulturist, physician, jurist and eminent citizen; a spiritual founder of the Cleveland Museum of Natural History and the Western Reserve Medical School.

Page 120. Omit "p.126" in first line.

Page 130. Last two lines should read ". . . also east to Crawford County, Pennsylvania, and Genesee County, New York."

Page 146. Fourth line from bottom should read ". . . collected it somewhere" instead of "collected somewhere."

Page 163. Supply the following, under original citation for **Rattus norvegicus** (Erxleben): *Type Locality.*— Norway.

Page 173. **Erithizon** should read **Erethizon.**

Page 180. Citation under **Kirtland, Jared Potter** should read 1838, not 1938.

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SCIENTIFIC PUBLICATIONS
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THE OHIO RECENT MAMMAL COLLECTION IN THE CLEVELAND MUSEUM OF NATURAL HISTORY

BY

B. PATTERSON BOLE, JR.
AND
PHILIP N. MOULTHROP

INTRODUCTION

Since the Cleveland Museum of Natural History was founded in 1920, a large collection of Ohio mammals has been gathered and is now deposited in this museum's department of mammals. This collection now numbers approximately 7000 specimens and is thus much larger than all other Ohio mammal collections put together. Included therein are representatives of every species of recent mammal recorded from the State, with but 9 exceptions. Of these exceptions, 5 are large species of rare occurrence even in pre-settlement days, which were swiftly extirpated with the coming of the white man. Virtually every section of Ohio is represented in this collection, although the great majority of the specimens have been taken within 50 miles of Cleveland.

Since the time of Dr. Jared P. Kirtland no serious taxonomic study of Ohio mammals has been made. Several excellent faunal papers have appeared, but all have followed the nomenclature current for more eastern or western states at their times of publication. The writers, faced with the prospect of early call to military service, therefore hasten to summarize the results of 10 years of research, incomplete for certain species as these may be.

The mammalogy of Ohio has long been assumed to be a simple subject, the species having been considered identical with the various forms described from the Atlantic Coast or certain Mississippi valley points. In other words, Ohio has not been regarded as a region of sufficient topographic diversity or geographical interest to warrant special collecting efforts. Nearly without exception, the State has been represented by a mere handful of specimens in the museums of outside states, and almost no material has been available for the recent revisions. The inadequacy of the 'life zone' theory of animal distribution in North America has nowhere been more clearly evident than in the subject of Ohio mammalogy. Ecologists have discovered en masse that Merriam's life-zones do not apply in Ohio, but taxonomists have failed to appreciate their findings.

To summarize the situation in Ohio, the following facts should be emphasized:

(1) There is, strictly speaking, no 'Upper Austral' or 'Transition' Zone in Ohio. The terms are meaningless. On the basis of plants alone, 'Upper Austral', 'Transition', and 'Canadian' zone areas can be found within a few miles or even rods of each other, especially in Geauga County.

(2) Several different climax forest types occur in Ohio, to wit: A beech-sugar maple climax on the glaciated Allegheny plateau, and many parts of the western till plains as well; an oak-chestnut forest occupying many sites in the central eastern section of the State, on both the glaciated and unglaciated plateaus; a mixed mesophytic forest covering the greater part of the unglaciated plateau; an oak-hickory forest occupying many isolated belts around 'prairie islands' on the till plains in the northern and northwestern portions of the State; and a pine-hemlock forest on the breaks of the Allegheny plateau in northeastern Ohio and scattered other points.

(3) There are extensive subclimax forest areas, such as the boreal tamarack .bogs of northeastern Ohio, the shortleaf pine-scrub of Washington and other southern Ohio counties, and the 'prairie islands' themselves.

(4) There are many different climates, the growing season exceeding 200 days in the extreme south and in the extreme north

along the Lake Erie plain, but falling below 100 days in parts of the Allegheny plateau in Ashtabula and Geauga counties; also decided variations in rainfall, from over 50 inches annually at Little Mountain in Lake and Geauga counties to less than 30 in northeastern Cuyahoga County only a few miles away, on the Lake Erie plain in the rain-shadow of the city of Cleveland.

(5) Ohio is not all flat. The unglaciated southeast is very hilly, in fact almost mountainous in Adams County, which is also an area of especially heavy rainfall for the State (over 40 inches annually). The myriads of deep, cool glens and rocky-walled ravines favor the persistence of northern small mammals, while warm, south-facing valleys favor the infiltration of southern forms.

(6) Two thirds of Ohio was glaciated during Wisconsin time, and geologically speaking, the ice left northern Ohio yesterday—about 35,000 years ago. As the ice retreated, the vegetation could not keep abreast of it, and in some places prairie, not conifer forest, followed the glacier. These prairie regions persisted as 'islands' till the coming of the white man, who forthwith enlarged them. The net result is a picture of incredible ecological complexity, and of rapidly shifting mammal populations, with several divergent faunal districts.

With these facts in mind, the results of a careful taxonomic study do not seem so surprising. This study was long delayed by the slowness of the authors to discard the prevailing belief that Ohio was, in its biology, after all very similar to the Atlantic seaboard. It was not possible of even successful initiation until topotypical series of most of the races of mammals reputedly occurring in Ohio had been collected or borrowed, and until a full understanding had been obtained of the sequence of pelages in each form. The study was delayed also by our failure immediately to recognize that the time of molt for certain Ohio species differed from that of the same or nearly related races elsewhere, a tendency particularly noticeable in northeastern Ohio. This is perhaps to be expected in a region where spring is long delayed by Lake Erie pack ice, and where frosts may occur at any time except in July and August, as is the case in parts of Geauga County and in interior Ashtabula County.

The names of colors employed in this report are based on those of Ridgway[1].

The great bulk of the specimens comprising the basis for this report was taken in the course of population studies made with the use of quadrats, the results of which have already been published.[2] Without the continued help and diligent interest of the authors' laboratory and field assistants in this work, the present paper could not have been completed. In this connection the authors are especially indebted to Mr. Scott R. Inkley and Mr. Winston C. Jesseman. Finally, the authors gratefully acknowledge the help and critical comments of their co-workers on the Cleveland Museum of Natural History staff, Mr. Arthur B. Fuller, Dr. David H. Dunkle, and Dr. Harry C. Oberholser.

For the loan of other specimens the writers are greatly indebted to Mr. Edward S. Thomas, of the Ohio State Museum; to Mr. Woodrow Goodpaster, of the Cincinnati Society of Natural History; to Mr. Clifford C. Gregg and Dr. Wilfred H. Osgood of the Field Museum of Natural History; to Dr. William H. Burt and Dr. Emmet T. Hooper of the University of Michigan Museum of Zoology; and to Dr. Hartley H. T. Jackson of the Fish and Wildlife Service (Biological Surveys). For permission to study their extensive collections and for their kindness in making their research facilities available, the senior author is still more indebted to the late Dr. Glover M. Allen of the Museum of Comparative Zoölogy at Harvard University; to Dr. Remington Kellogg of the United States National Museum; and again, to Doctor Jackson.

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[1]Color Standards and Color Nomenclature, 1912 [January 16, 1913], pp. [1-4], i-iv, 1-44, frontispiece, pls. I-LIII.

[2]Scient. Publ. Cleve. Mus. Nat. Hist., Vol. V, No. 4, December 28, 1939.

MAMMALS OF OHIO

Didelphis virginiana virginiana Kerr

VIRGINIA OPOSSUM

Didelphis virginiana KERR, Animal Kingdom, 1792, p. 193.

Type Locality.—"Virginia".

Opossums from Ohio are apparently indistinguishable from examples taken along the middle Atlantic seaboard. In Ohio the species appears in 2 color phases, the usual one with gray guard hairs, and another, a much rarer dark phase in which the guard hairs are blackish. Opossums are to be found today in all parts of the State, but there is some evidence that their arrival in northeastern Ohio is of comparatively recent date, as the species is very uncommon in bone finds in this region, and occurs only in those of very recent origin.

Ohio specimens examined.[1]—

CUYAHOGA COUNTY.—Chagrin Falls, 1; Cleveland, 1; Cleveland Heights,1; Dover, 1; Gates Mills,1; Orange, 1; Pepper Pike, 1.

GEAUGA COUNTY.—Chardon, 1.

LAKE COUNTY.—Kirtland Hills, 2; Madison, 2; Mentor, 2; Wickliffe, 1; Willoughby, 1.

OTTAWA COUNTY.—Ottawa Co. (no further locality), 1.

PORTAGE COUNTY.—Aurora Pond, 2; Geauga Lake, 1.

SANDUSKY COUNTY.—Fremont, 1.

SENECA COUNTY.—Bettsville, 2; Feaselburg, 1.

STARK COUNTY.—Waynesburg, 1.

SUMMIT COUNTY.—Everett, 2.

Scalopus aquaticus machrinus (Rafinesque)

PRAIRIE MOLE

Talpa machrina RAFINESQUE, Atlantic Journal, Vol. I, 1832, p. 61.

Type Locality.—Near Lexington, Fayette County, Kentucky.

The prairie mole has been reported from all parts of Ohio, but can now be unequivocally stated to be lacking from the northeastern quarter of the State, and certainly to be rare over much

[1]All specimens listed in the present paper are from the collection of the Cleveland Museum of Natural History unless otherwise indicated.

of the southeast as well. In the western half of the State it is locally abundant, and specimens from this section are typical of *S. a. machrinus*. There is a local tendency towards large size in northwestern Ohio.

Ohio specimens examined.—

Adams County.—Smoky Creek, Green Township, 2.
Clermont County.—Union Township, 2.
Erie County.—Ceylon Junction, 1.
Mercer County.—Celina, 1.
Seneca County.—Bettsville, 8; Bunker Hill, 1; Old Fort, 1.

Parascalops breweri (Bachman)

Hairy-tailed Mole

Scalops breweri Bachman, Boston Journ. Nat. Hist., Vol. III, 1842, p. 32.

Type Locality.—According to Bachman, Marthas Vineyard Island, Massachusetts. Repeated efforts by numerous collectors, including the senior author, to trap this species there have to date been unavailing.

This species is the common mole of eastern Ohio, particularly of northeastern Ohio. In some areas of extreme southern Ohio (Lawrence County) it occupies the same ground as *Scalopus*, but the overlap of the ranges is very narrow. Ohio-caught specimens seem identical with examples from New York and New England.

Ohio specimens examined.—

Ashtabula County.—Mechanicsville, 1.
Columbiana County.—Lisbon, 1.
Cuyahoga County.—Brecksville Metropolitan Park, 4; Chagrin Falls, 6; Gates Mills, 4; Lyndhurst, 1; North Chagrin Metropolitan Park, 2; North Olmsted, 1; Rocky River Metropolitan Park, 3.
Fairfield County.—Greenfield Township, 1.
Geauga County.—Auburn Corners, 1; Burton Bog, 2; Chesterland Caves, 1; Lake Punderson, 1; Little Mountain, 29; Shady Lake, 3; Middlefield Township, 1; Thompson Township, 1.
Lake County.—Holden Arboretum, 21; Mentor, 4; Mentor Headlands, 1; Pleasant Valley, 1; Wickliffe, 1; Willoughby, 2.
Lawrence County.—Ironton, 1.
Portage County.—Aurora Pond, 1; Geauga Lake, 1.
Stark County.—Waynesburg, 1.
Summit County.—Darrowville, 1.

Condylura cristata cristata (Linnaeus)

STAR-NOSED MOLE

[*Sorex*] *cristatus* LINNAEUS, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 53.

Type Locality.—Pennsylvania.

The description of *Condylura cristata nigra* R. W. Smith[1] necessitates the use of a trinomial for the typical race. Ohio examples of *Condylura c. cristata* differ from those of *C. c. nigra* from Nova Scotia in size as well as color, being smaller and slightly paler. The differences appear even more pronounced when comparison is made with specimens from coastal Maine.

The star-nosed mole is locally abundant in northeastern Ohio, especially on boggy ground and along slow-moving woodland streams. Elsewhere the species is decidedly uncommon.

Ohio specimens examined.—

ASHTABULA COUNTY.—Padanaram, 4.

CUYAHOGA COUNTY.—Chagrin Falls, 1; Gates Mills, 2; North Chagrin Metropolitan Park, 1.

GEAUGA COUNTY.—Auburn Corners, 3; Burton Bog, 1; Little Mountain, 2; Munson Township, 2; Shady Lake, 1.

LAKE COUNTY.—Holden Arboretum, 11; Kirtland Hills, 1; Mentor Marsh, 1.

PORTAGE COUNTY.—Aurora Pond, 6.

SUMMIT COUNTY.—Northfield (owl pellet record), 1.

Sorex cinereus ohionensis, subsp. nov.

OHIO SHREW

Type.—Adult male, skin and skull, No. 16901, Cleveland Museum of Natural History; April 5, 1942; Wilbur B. Quay.

Type Locality.—Hunting Valley, Cuyahoga County, Ohio.

Range.—Northern Ohio, from Ashtabula County at least as far west as Seneca County.

Diagnosis.—A very small race, the third unicuspid of which is usually smaller than the fourth, in this respect differing from all other races of *Sorex cinereus;* it is diminished in all external and cranial measurements; and also has a distinctive dark gray winter pelage and poorly pigmented teeth.

Color.—Winter pelage (the type). Upper parts fuscous to fuscous black, suffused with gray, the colors extending half way

[1]Amer. Midl. Nat., Vol. XXIV, No. 1, July, 1940, p. 218.

down the sides; underfur blackish slate; sides exhibiting a narrow, poorly defined band of dusky drab; under parts light gull gray with slate gray underfur; tail fuscous above, vinaceous buff below; upper surface of feet pale ochraceous buff. *Fresh summer pelage* (No. 15929, C.M.N.H., Holden Arboretum, Lake County, Ohio). Upper parts snuff brown; sides of head and body sayal brown. *Worn summer pelage* (No. 7307 C.M.N.H., Aurora Pond, Portage County, Ohio). Upper parts buffy brown, gradually becoming wood brown on sides; tail above wood brown; under parts pale smoke gray faintly washed with buff.

Skull.—Very small, with braincase greatly shortened and flattened; unicuspid tooth row shortened and crowded; teeth poorly pigmented; mandible short.

Measurements.—Type: length, 93.5 mm.; tail, 34.5; hind foot, 11; condylobasal length of skull, 14.7; palatal length, 5.6; cranial breadth, 4.2; maxillary tooth row, 5.3; length of mandible, 8.8. *Twenty topotypes* average, with minimum and maximum: length, 94.3 (88-99); tail, 35.0 (32-38); hind foot, 11.3 (10-12); condylobasal length of skull, 15.1 (14.6-15.9); palatal length, 5.8 (5.5-6.0); cranial breadth, 7.5 (7.2-7.8); interorbital breadth, 2.8 (2.7-3.0); maxillary breadth, 4.1 (3.8-4.2); maxillary tooth row, 5.3 (5.1-5.4); length of mandible, 8.9 (8.7-9.2). *Ten specimens from the Holden Arboretum, Lake County, Ohio,* average: length, 91.6; tail, 34.6; hind foot, 11.4. *Ten specimens from Mentor Marsh, Lake County, Ohio,* average: length, 92.8; tail, 35.0; hind foot, 11.4. *Ten specimens from Maple Grove, Seneca County, Ohio,* average: length, 93.0; tail, 31.8; hind foot, 10.6. *Twenty specimens from Aurora Pond, Portage County, Ohio,* average: length, 93.1; tail, 34.4; hind foot, 11.1.

Remarks.—In determining the proper designation for the *Sorex cinereus* of Ohio, it was necessary first to weigh the possible availability of 2 names now in the synonomy of the species. In 1842 Duvernoy[1] described *Amphisorex lesueurii,* with the type locality as the Wabash River valley, Indiana. The name *lesueurii* persisted for several years, sometimes as *Sorex personatus lesueurii*[2]. Shrews of the species *Sorex cinereus* are apparently very rare in Indiana[3], especially so in the southern part of the State. Jackson[2]

[1]Mag. de Zool. d'Anat. Comp. et de Palaeont., series 2, Vol. IV, 1842, Monogr. du Genre Musaraigne, p. 33.
[2]Jackson, North Amer. Fauna, No. 51, July, 1928, pp. 41-46 and 85-86.
[3]Lyon, Amer. Midl. Nat., Vol. XVII, No. 1, 1936, pp. 42-43.

assigns the Indiana *Sorex cinereus* to the typical subspecies on the basis of 5 specimens seen, but points out that the measurements of a controversial specimen from New Harmony, Posey County, are well below the average for the race, a tendency observable in examples from nearly all parts of the southern limits of the range of the species. However, an example in the U. S. Biological Surveys collection from St. Joseph County, Indiana, in winter pelage is almost black, with unusually dark under parts, presenting a rich velvety appearance, the darkest by far of all the specimens of *Sorex cinereus* seen in the course of the present investigation. Since Ohio specimens from Seneca County taken in April are somewhat darker and more richly colored than those from the Cleveland region in the same month, the Seneca County series shows evidence of intergradation with a darker, subspecifically distinct, but hitherto unrecognized Indiana stock to which, in the authors' opinion, the name *Sorex cinereus lesueurii* should apply.

The other old name to be considered, *Sorex fimbripes* Bachman[1] (type locality, Drury Run, Clinton Co., Pennsylvania), appears to represent intergradation between *Sorex cinereus fontinalis* Hollister[2] and *Sorex cinereus cinereus* Kerr, both geographically and on the basis of measurements given by Jackson[3]. A less conservative reviewer than Doctor Jackson might well have recognized the shrew of the southern Appalachian highlands as sufficiently different to merit subspecific recognition, in which case this name *Sorex cinereus fimbripes* might apply.

From Ohio Doctor Jackson was able to examine but 3 specimens. Since his paper was written, the Cleveland Museum of Natural History has obtained over 180 specimens from northern Ohio, which have provided the most difficult taxonomic problems of the current project.

In the first place, the Ohio form is extremely variable colonially and individually, much more so than is *Sorex cinereus cinereus*. A series from Great South Bog, Geauga County, is characterized by the presence of irregular rows of white spots or flecks in greater or lesser degree, surely a most astonishing character for a shrew of the genus *Sorex*. Specimens from North Chagrin Park, Cuyahoga

[1]Journ. Acad. Nat. Sci. Philadelphia, Vol. VII, Part 2, 1837, p. 391.
[2]Concerning the subspecific status of *Sorex fontinalis* see Poole, Journ. Mamm., Vol. XVIII, February, 1937, p. 96.
[3]Loc. cit.

County, show practically no pigment in the teeth, 2 specimens from this locality being absolutely without dental pigment. A specimen from the Holden Arboretum, Lake County, apparently a freak, is gull gray in color and almost white underneath. Several specimens out of a large series from Aurora Pond, Portage County, are saddle backed in summer pelage like *Sorex arcticus*, while some resemble *Sorex cinereus haydeni*. Many specimens from this locality at the same time of year show no tricolored pattern at all; and every degree of variation occurs between the 'saddle-backs' and those shrews with the dorsal coloration extending down the sides to meet the ventral coloration. In the last category, the uniform dorsal color may be sayal brown or snuff brown in one individual, and deep brownish drab in another. All our larger series of summer specimens to some extent show this pelage variability. The greatest variation occurs in the summer color of the under parts; pale pinkish buff, pinkish buff, vinaceous buff, avellaneous, wood brown, pallid brownish drab, pale drab gray, pale smoke gray, smoke gray, and pale gull gray, to mention some of the phases. It has been impossible to correlate with either sex or age the various phases shown by Ohio specimens.

Our winter-caught specimens show none of this variability. The under parts in winter are usually between pale gull gray and light gull gray, occasionally slightly darker or lighter. For this reason the winter pelage is most suitable for comparisons. In northeastern Ohio, animals in winter pelage may be taken from late October to late April. Plateau specimens generally assume their winter pelages earlier and their summer pelages later than examples from the lake plain.

Because of the many shades of brown in the summer pelages of *Sorex cinereus ohionensis*, specimens of *Sorex cinereus fontinalis* Hollister are lost in the Ohio series, and the color of *S. cinereus cinereus* Kerr from the type region of Ontario can be perfectly matched. Likewise, many Ohio specimens are as reddish as North Carolina specimens of *Sorex longirostris longirostris* Bachman.

But that is not all. The majority of the Ohio specimens display a tendency toward having the third unicuspid tooth smaller than the fourth; and frequently the first and second unicuspids are noticeably larger than the third and fourth; in some this character is developed to an extent comparable to that found in certain far

western shrews, and far more than in *S. longirostris*. Rarely is the fourth unicuspid smaller than the third; often the 2 are of the same size; usually the third is slightly smaller; and all degrees of intergradation between the extremes occur. Consequently, the key to subspecies in Jackson's revision[1] will not work for most specimens from Ohio. The 2 factors so far enumerated—extreme variability of color and the small third unicuspid—are sufficient basis for balking at assigning the Ohio form to *Sorex cinereus cinereus* Kerr. The very small size of the Ohio specimens adds yet another reason.

Remington Kellogg[2] noted the tendency toward the smaller third unicuspid in a series of *Sorex cinereus* from Roan Mountain, North Carolina, and to a less degree in specimens from Suffolk County and Franklin County, New York. He then compared 10 Maryland skulls of *Sorex cinereus fontinalis* with 10 skulls of *S. longirostris* from various parts of its range, and came to the conclusion that the supposed distinctions between the 2 species were nothing more than individual variations. However, winter specimens of *longirostris* in the U. S. Biological Surveys collection may be easily distinguished from winter specimens of *fontinalis* by the reddish color of the former; in addition, *longirostris* is characterized by its slender feet, its short, delicate tail, and trenchant cranial characters other than those dealing with the unicuspid teeth. With tooth characters so unstable in the southern forms of *Sorex cinereus* it now seems more desirable to use the winter pelage as a basis for comparisons not only with the races of *S. cinereus* but of *S. longirostris* as well.

The student may well ask why the shrew here being discussed is not referred to *Sorex longirostris*. Compared to *longirostris* this animal is, however, very different. The cranial proportions, aside from the character of the third unicuspid, are those of *S. cinereus*. Specimens of *Sorex longirostris* in the U. S. Biological Surveys collection have short, flat, broad skulls, a full millimeter shorter than the Ohio specimens in question, with heavier, proportionately larger molar teeth. The robustly proportioned feet of the Ohio specimens are typical of *S. cinereus*, although the inflation of the Ohio skulls is somewhat intermediate between that of *S. longirostris* and *S. cinereus cinereus*, as is also the case with *fontinalis*. This

[1]Loc. cit.
[2]Proc. U. S. Nat. Mus., Vol. LXXXVI, No. 3051, February 14, 1939, pp. 249-251.

reduced inflation, however, seems to be another of the highly variable characters of the Ohio race, topotypical specimens ranging from 4.2 mm. to 4.8 in height of braincase, and examples in the Aurora Pond series from 4.2 to 5.0.

The dark gray winter pelage of the Ohio race also serves for a basis of separation from *Sorex longirostris*, which is a reddish brown animal during both winter and summer. Similarly, *Sorex cinereus fontinalis* is a brownish shrew in winter pelage. A series of winter *S. cinereus cinereus* from Toronto, Ontario, is paler and more brownish than *S. c. ohionensis*. Partially molted spring specimens of the typical subspecies from the Upper Peninsula of Michigan and from Taunton, Massachusetts, show a brownish winter pelage. One winter example from the Bergen Swamp, Genesee County, New York, shows evidence of intergradation between the Ohio race and typical *cinereus*. On the basis of this specimen we might expect to find *Sorex c. ohionensis* entering western New York along the lake plain.

A topotype, No. 16206, C.M.N.H., presents an amazing anomaly in lacking one unicuspid tooth on each side, leaving a unicuspid tooth row of 3 larger teeth followed by 1 very small, peg-like tooth. The skull of this individual is perfectly proportioned and symmetrical, with slightly worn teeth. Still another topotype lacks 1 unicuspid tooth on one side, but this specimen's unicuspid tooth row is obviously deformed.

A large series collected by Morton L. Church on Seal Island, Guysborough County, Nova Scotia, is not typical of *S. c. cinereus* and may be referable to *S. c. acadicus* Gilpin.

In the course of this study it was found that a series of both winter and summer *Sorex cinereus* from Mays Landing, Atlantic County, New Jersey, could not be referred to *S. cinereus nigriculus* Green (type locality at the Tuckahoe River, east of Tuckahoe, Cape May County, New Jersey) on the basis of the description given by that author.[1]

Specimens examined.—

Sorex cinereus ohionensis

Ohio.—Geneva, Ashtabula Co., 3; Mechanicsville, Ashtabula Co., 2; Bedford, Cuyahoga Co., 4; Chagrin Falls, Cuyahoga Co., 3; Hunting Valley,

[1]Univ. Calif. Publ. Zool., Vol. XXXVIII, No. 7, 1932, pp. 387-388.

Cuyahoga Co. (type locality), 30; North Chagrin Metropolitan Park, Cuyahoga Co., 5; Pepper Pike, Cuyahoga Co., 4; Solon, Cuyahoga Co., 1; Auburn Corners, Geauga Co., 3; Great South Bog, Geauga Co., 9; Lake Punderson, Geauga Co., 1; Black Brook, Lake Co., 1; Holden Arboretum, Lake Co., 15; Mentor Marsh, Lake Co., 20; Wellington, Lorain Co., 1 (owl pellet record); Aurora Pond, Portage Co., 67; Maple Grove, Seneca Co., 10; Northfield, Summit Co., 2 (owl pellet records).

Sorex cinereus cinereus

Manitoba.—Churchill, 1.

Nova Scotia.—Seal Island, Guysborough Co., 18 (not typical).

Ontario.—South shore of Lake Nipissing, Parry Sound Co., 1; Aurora, York Co., 2; Toronto, York Co., 10.

Quebec.—Bark Lake, Pontiac Co., 4.

Maine.—Vinalhaven, Knox Co., 1; Mooselookmeguntic Lake, Franklin Co., 1; Kimball Island, Hancock Co., 1.

Massachusetts.—Essex, Essex Co., 1; Taunton, Bristol Co., 1; Monomoy Island, Barnstable Co., 1.

Michigan.—Newberry, Luce Co., 6; Waters, Otsego Co., 1.

New Hampshire.—Pittsburg, Coos Co., 3; Mt. Moosilauke, Grafton Co., 1.

New Jersey.—Tuckerton, Ocean Co., 1 (U. S. Biological Surveys coll.); Mays Landing, Atlantic Co., 8 (2 in U. S. Biological Surveys coll.).

New York.—Giant Mountain, Essex Co., 1; Peterboro, Madison Co., 12; Bergen Swamp, Genesee Co., 1; Elba, Genesee Co., 2.

North Carolina.—Mt. Mitchell, Yancey Co., 1 (U. S. Biological Surveys coll.); Grandfather Mountain, Watauga Co., 1 (U. S. Biological Surveys coll.).

Vermont.—Wells River, Orange Co., 1.

West Virginia.—Cheat Bridge, Randolph Co., 4 (U. S. National Museum); Cranberry Glades, Pocahontas Co., 1 (U. S. National Museum).

Sorex cinereus haydeni

South Dakota.—Bull Springs, Custer Co., 1.

Sorex cinereus lesueurii

Indiana.—Liberty Township, St. Joseph Co., 1 (U. S. Biological Surveys coll.).

Sorex cinereus fontinalis

Maryland.—Hyattsville, Prince George Co., 2 (U. S. Biological Surveys coll.); Cambridge, Dorchester Co., 1 (U. S. Biological Surveys coll.).

Sorex longirostris longirostris

North Carolina.—Raleigh, Wake Co., 1 (U. S. Biological Surveys coll.); Pisgah Forest, 1 (U. S. Biological Surveys coll.).

Sorex fumeus fumeus Miller

APPALACHIAN SMOKY SHREW

Sorex fumeus MILLER, North Amer. Fauna, No. 10, December 31, 1895, p. 50.

Type Locality.—Peterboro, Madison County, New York.

The smoky shrew, in Ohio, is confined to the Allegheny plateau, where it has been recorded from Ross County[1], northeastward through the Cleveland region to the Pennsylvania state line at Pymatuning Lake. It thus seems largely restricted to the glaciated portion of the plateau, avoiding the plains portion of the State, and apparently straying but a short distance into the unglaciated southeast. Further trapping, however, may disclose its presence deep within the lattermost province.

On the drainage area of the Chagrin River in Lake, Geauga, and eastern Cuyahoga counties, *Sorex fumeus* is one of the most abundant mammals and occurs in almost every rich beech-hemlock woodland. Because of this local concentration, the Cleveland Museum of Natural History has amassed large series of specimens taken at all seasons of the year. There is in these series some variation from place to place, although those from any given locality seem to be fairly constant. This variability manifests itself chiefly in size. Compared to topotypes from Peterboro, New York, all the Ohio specimens are very slightly paler and more reddish in summer pelage, and most are smaller. There are also minor cranial differences, but the range of overlap is great; therefore it seems best to assign the Ohio form definitely to *Sorex fumeus fumeus*. The characters that the Ohio series show are but slight intensifications of the features differentiating topotypical *Sorex fumeus fumeus* from *Sorex fumeus umbrosus* Jackson. Compared to a series from Aurora, York County, Ontario, the Ohio series differ to the same slight degree. There is more aberrance between a series of Ohio *S. f. fumeus* and a series from St. Huberts, Essex County, New York, some specimens of which are near *S. f. umbrosus*. Examples from Bergen Swamp, Genesee County, New York, are much larger than either the Ohio, Ontario, or topotypical specimens.

[1]Enders, Occ. Papers Mus. Zool. Univ. Mich., No. 212, April 23, 1930, p. 8.

Specimens examined.—

Ontario.—Aurora, York Co., 11.

Kentucky.—Mammoth Cave, Edmondson Co., 2 (U. S. Biological Surveys coll.).

New Hampshire.—Jaffrey, Cheshire Co., 1.

New York.—St. Huberts, Essex Co., 21; Bergen Swamp, Genesee Co., 8; Peterboro, Madison Co., 4 (topotypes).

Ohio.—Andover, Ashtabula Co., 1; Mechanicsville, Ashtabula Co., 1; Brecksville Metropolitan Park, Cuyahoga Co., 8; Chagrin Falls, Cuyahoga Co., 1; Gates Mills, Cuyahoga Co., 1; North Chagrin Metropolitan Park, Cuyahoga Co., 23; Carvers Pond, Geauga Co., 1; Chesterland Caves, Geauga Co., 4; Little Mountain, Geauga Co., 124; Munson Township, Geauga Co., 1; Stebbens Gulch, Geauga Co., 2; Holden Arboretum, Lake Co., 96; Kirtland Hills, Lake Co., 1; Aurora Pond, Portage Co., 28; Northfield, Summit Co., 1 (owl pellet record).

Vermont.—Wells River, Orange Co., 1.

West Virginia.—Spruce Knob, Pendleton Co., 1 (U. S. National Museum); Cranberry Glades, Pocahontas Co., 2 (U. S. National Museum); Odd, Raleigh Co., 1 (U. S. National Museum); Cheat Bridge, Randolph Co., 1 (U. S. National Museum).

Cryptotis parva elasson, subsp. nov.

Gray Cryptotis

Type.—Adult female, skin and skull, No. 14025, Cleveland Museum of Natural History; February 1, 1939; Winston C. Jesseman, original number, 685.

Type Locality.—Bettsville, Seneca County, Ohio.

Range.—Ohio, intergrading with *Cryptotis parva harlani* (Duvernoy) along the Ohio-Indiana boundary.

Diagnosis.—The smallest cryptotis; very grayish with rostrum and tooth row much shortened; and with deeply pigmented teeth.

Color.—*Winter pelage* (the type). Upper parts slightly glossy, between fuscous and deep mouse gray; underfur slate gray; lower surface glossy gull gray; upper surfaces of feet gull gray; tail above like upper parts, below nearly white. *Fresh summer pelage* (No. 12878, C. M. N. H., a topotype, early June). Slightly paler, more grayish, and less glossy than the type, otherwise very similar. *Worn summer pelage* (No. 13771, C. M. N. H., a topotype, October). Still paler and more grayish, near mouse gray.

Skull.—Very small, low-crowned, and with relatively broad cranium; teeth small, deeply pigmented; unicuspid tooth row crowded, shortened; maxillary projections well developed.

Measurements.—Type: Length, 76 mm.; tail, 12; hind foot, 9; condylobasal length of skull, 14.4; palatal length, 6.4; maxillary breadth, 7.6; interorbital constriction 3.5; length of tooth row (from anterior border of i_2), 5.5.

Remarks.—A cryptotis, taken by Lesueur, was described from New Harmony, Indiana, in 1842 by Duvernoy, as *Sorex harlani*[1]. A specimen at hand from New Harmony is easily separable from either *Cryptotis parva elasson* or topotypical *C. p. parva* from Blair, Nebraska. In the opinion of the authors, the cryptotis of Indiana represents a recognizable race which should stand as *Cryptotis parva harlani* (Duvernoy).

Compared to *C. p. harlani*, *C. p. elasson* is much smaller in all proportions; much more grayish; its dentition is much weaker and less heavily pigmented. Certain skulls, recovered from owl pellets, taken in Steuben and Adams Counties, Indiana, and in Paulding County, Ohio, are somewhat intermediate. There is apparently no close relationship between true *C. p. parva* and *C. p. elasson*, since the differences might be considered of specific rather than subspecific proportions. However, *C. p. harlani* affords in this connection a very distinctive link; it is of the size of *parva*, but is of a much darker color, and is considerably more grayish, indicating an approach to *elasson*. So extreme are the differences between *parva* and *elasson*, however, that there is ample room for 1 or even 2 intermediate races. A specimen from Bloomington, Illinois, is strictly intermediate between *C. p. parva* and *C. p. harlani*, but is herein assigned to the latter form.

The subspecies *C. p. elasson* is Ohio's smallest mammal. It is very difficult to trap, as it moves with its back highly arched so that in motion the shrew looks like a little round ball of fur. In this position it is so short (far less than in an extended skin or dead specimen) that ordinary mousetraps will snap over the intended victim and throw the animal clear of the trap. Most of the specimens listed below were taken as the result of accidents of one sort or another; only a few were trapped. That the species is far more abundant than trapping records show is indicated by the regularity with which the species is recovered from owl pellets. The 27 specimens of this shrew taken from owl pellets collected

[1]Mag. de Zool., 1842, Mon. XL, pl. liii, texte p. 6.

at Evansport, Defiance County, Ohio, comprised more than 25 percent of the mammal records from this source.

Specimens examined.—

Cryptotis parva elasson

Ohio.—Geneva, Ashtabula Co., 2; Lyndhurst, Cuyahoga Co., 1; North Chagrin Metropolitan Park, Cuyahoga Co., 1; Big Creek, Madison Township, Lake Co., 2; Mentor, Lake Co., 2; Bay Point, Ottawa Co., 1; Aurora Pond, Portage Co., 1; Bettsville, Seneca Co. (type locality), 7. *Owl pellet skulls:* Smoky Creek, Green Township, Adams Co., 1; Austinburg, Ashtabula Co., 1; Evansport, Defiance Co., 27; Mentor, Lake Co., 9; Kipton, Lorain Co., 13; Oberlin, Lorain Co., 9; Antwerp, Paulding Co., 24; Paulding, Paulding Co., 1; Northfield, Summit Co., 2.

Cryptotis parva harlani

Illinois.—Bloomington, McLean Co., 1.

Indiana.—New Harmony, Posey Co., 1; Terre Haute, Vigo Co., 1 (U. S. Biological Surveys coll.). *Owl pellet skulls:* Pleasant Mills, Adams Co., 7; Orland, Steuben Co., 2.

Cryptotis parva parva

Nebraska.—Blair, Washington Co., 9 (topotypes; all in U. S. Biological Surveys coll.).

Texas.—Victoria, Victoria Co., 1.

Blarina brevicauda kirtlandi, subsp. nov.

Lake States Blarina

Type.—Young adult male, skin and skull, No. 16895, Cleveland Museum of Natural History; October 13, 1939; B. Patterson Bole, Jr., original number, X-881.

Type Locality.—The Holden Arboretum, Kirtland Township, Lake County, and Chardon Township, Geauga County, Ohio. (The county line bisects the type locality.)

Range.—From northwestern Michigan, central Wisconsin, and central Illinois, east to southeastern West Virginia, eastern Pennsylvania, and southwestern New York.

Diagnosis.—A medium-sized, dark-colored, stockily-built, short-tailed blarina with the proportionately shortest, broadest feet, and most strongly recurved maxillary projections of any race of *Blarina brevicauda.*

Color.—*Fresh winter pelage* (the type). Upper parts very dark slate gray, with light silvery gloss; under parts very little lighter

than back, the hairs narrowly tipped with dull silver; an indistinct brownish wash on throat and belly; upper surface of hind feet lightly covered with short black hairs along the outer edges, and with short whitish hairs along the inner; tail blackish above, light silvery gray below; forearms densely clothed with long, conspicuous, silvery hairs. *Fresh summer pelage* (No. 12935, C. M. N. H., early July; a paratype). Upper parts sooty grayish black, with very little gloss; under parts like upper surface; tail black above and below; forearms clothed with inconspicuous sooty blackish hairs; most of upper surface of hind feet covered with black hairs.

Skull (of type).—Of medium proportions for a blarina; foramen magnum very large; occipital steeply sloping; posterior maxillary projections sharply hooked and recurved, terminating in a plane vertically bisecting m_3; pm_1 (fifth unicuspid) without pigment; other teeth well pigmented; cranium low crowned.

Measurements.—Type: total length, 116 mm.; tail, 22; hind foot, 14; condylobasal length of skull, 21.0; interorbital constriction, 6.0; maxillary breadth, 7.6; palatal length, 10.0; mastoid breadth, 11.9; tooth row (from anterior border of i_2), 8.9; width of foramen magnum, 3.2; weight (in flesh), 15.5 grams.

Remarks.—This race, *Blarina brevicauda kirtlandi*, differs from all other forms of the genus *Blarina* in the great development of the maxillary projections; in the large size of the foramen magnum; and in having relatively the shortest and broadest feet. In other characters it is intermediate between other forms, as one might expect from its geographical position. It is very short-tailed; this becomes apparent only when series from all over the range are compared, series from the type locality being less remarkable in this regard than are the shortest-tailed stocks from northwestern Ohio. The type series, however, best illustrates the other characteristics of the race.

Every one of the forms of *Blarina brevicauda* heretofore described has its type locality peripherally situated with respect to the range of the species as a whole. This situation has led to endless confusion in museums whose workers have attempted to allocate their specimens properly. The situation has further been complicated by the fact that for some of the forms topotypes are hard to obtain; that there is almost no color range in the species;

and that the range in measurements of any given series from any one locality is usually tremendous. Trenchant proportional differences appear when large series are measured, however, and the color characters, while slight, are remarkably constant. It proved impossible to identify the Ohio blarina for the purposes of this paper until a revision of the genus was undertaken. This enterprise is far from completed at the present time, but with the senior author faced with the prospect of an early call to military service, it seems best to publish the results so far obtained in the course of the study.

The subspecies *Blarina b. kirtlandi*, herein described, is the short-tailed shrew of the 'blarina belt', that is, the tier of states south of the Great Lakes, where *Blarina brevicauda* is the commonest mammal, and where every trapper is plagued with a continual bumper crop of this species. From a population standpoint, it is probably safe to say that 75 percent of all blarinas belong to this race, which constitutes the central stock of the species, being intermediate in its characters and geographical distribution. It differs from the type race *Blarina brevicauda brevicauda* in being much smaller in all dimensions, the maximum measurements of *kirtlandi*, obtained from hundreds of topotypes and thousands of specimens, barely overlapping the minimum of *brevicauda* from the latter's type region. It differs from *brevicauda* also in cranial characters and in color, being less sooty black and having little or none of the deep brownish gloss seen in fresh pelages of *brevicauda*.

From *Blarina brevicauda talpoides*, the common northeastern form, *B. b. kirtlandi* differs in being much smaller, shorter and broader footed, darker colored, less suffused with silvery iridescence in comparable pelages, and in having a low-crowned, robustly proportioned skull as opposed to the high-crowned, lightly built skull of *talpoides*. The dentition of *kirtlandi* is much the more heavily pigmented. The maxillary projections of *talpoides*, less well developed, usually terminate in a plane bisecting the *anterior* instead of the middle portions of m_3.

From *Blarina brevicauda carolinensis*, this new subspecies may be readily distinguished by various cranial characters and by its very much greater size, the disparity in this regard being even greater than between it and *B. b. brevicauda*. The minimum measurements

of the topotypical series of *B. b. kirtlandi* are in all cases far above the maximum of a series of topotypical *B. b. carolinensis.*

From the blarina of the Great Smoky Mountains region, described below as new, *Blarina b. kirtlandi* may be separated by its lighter coloration, smaller foot, and much shorter tail. Intergradation is not shown in the material so far examined by the writers, specimens from southeastern West Virginia being in every way typical of *kirtlandi.* From other races of *Blarina brevicauda* so far described, *kirtlandi* differs sharply in so many characteristics that close comparison is scarcely needed. It must always be remembered, however, that between *Blarina brevicauda compacta,* the palest of eastern blarinas, and the Great Smoky form, darkest of the series, there is much less color difference than between the extremes of most other species of small mammals.

Specimens examined.—

INDIANA.—Lagrange Co., 1 (Univ. Michigan Mus. Zool.); Schneider, Lake Co., 1 (Univ. Michigan Mus. Zool.); New Harmony, Posey Co., 14.

ILLINOIS.—Bloomington, McLean Co., 26 (*kirtlandi-brevicauda* intergrades).

MICHIGAN.—Alger Co., 5 (Univ. Michigan Mus. Zool.); Warren Woods, Berrien Co., 6 (Univ. Michigan Mus. Zool.); Boyne Falls, Charlevoix Co., 19 (Univ. Michigan Mus. Zool.) Fish Hawk Lake, Gogebic Co., 6 (Univ. Michigan Mus. Zool.); Golden Lake, Iron Co., 1; Two Hearted River, Luce Co., 6 (Univ. Michigan Mus. Zool.); Newberry, Luce Co., 5; Banat, Menominee Co., 10 (Univ. Michigan Mus. Zool.); Roscommon Co., 2 (U. S. Biological Surveys coll.); Ann Arbor, Washtenaw Co., 13 (Univ. Michigan Mus. Zool.); Portage Lake, Washtenaw Co., (Univ. Michigan Mus. Zool.); Saline, Washtenaw Co., 1 (Univ. Michigan Mus. Zool.).

OHIO.—Smoky Creek, Adams Co., 9; Andover, Ashtabula Co., 6; Farnham, Ashtabula Co., 5; Mechanicsville, Ashtabula Co., 39; Cat Run, Belmont Co.. 22; Ripley, Brown Co., 5; Middlefield, Butler Co., 1; Reily, Butler Co., 2; Chilo, Clermont Co., 2; Union Township, Clermont Co., 1; Lisbon, Columbiana Co., 33; Bedford, Cuyahoga Co., 21; Brecksville, Cuyahoga Co., 16; Chagrin Falls, Cuyahoga Co., 53; Cleveland, Cuyahoga Co., 3; Cleveland Heights, Cuyahoga, Co., 8; Euclid, Cuyahoga Co., 3; Gates Mills, Cuyahoga Co., 55; Lyndhurst, Cuyahoga Co., 44; North Chagrin Metropolitan Park, Cuyahoga Co., 179; Pepper Pike, Cuyahoga Co., 9; Richmond Heights, Cuyahoga Co., 7; Rocky River Metropolitan Park, Cuyahoga Co., 17; South Euclid, Cuyahoga Co., 3; University Heights, Cuyahoga Co., 18; Lancaster, Fairfield Co., 1; Auburn Corners, Geauga Co., 9; Carvers Pond, Geauga Co., 8; Chesterland Caves, Geauga Co., 44; Great South Bog, Geauga Co., 33; Holden Arboretum, Geauga Co., 22 (topotypes); Lake Punderson, Geauga Co., 16; Little Mountain, Geauga Co., 340; Middlefield, Geauga Co., 12; Munson Town-

ship, Geauga Co., 15; Thompson Township, Geauga Co., 45; Parkman, Geauga Co., 8; Shady Lake, Geauga Co., 14; Stebbens Gulch, Geauga Co., 11; Cincinnati, Hamilton Co., 3; Fostoria, Hancock Co., 15; Holden Arboretum, Lake Co., 135 (the type and 134 topotypes); Kirtland Hills, Lake Co., 20; Leroy Township, Lake Co., 6; Madison Township, Lake Co., 4; Mentor Harbor, Lake Co., 4; Mentor Marsh, Lake Co., 24; Richmond Beach, Lake Co., 18; Wickliffe, Lake Co., 2; Symmes Creek, Lawrence Co., 6; Celina, Mercer Co., 4; Fort Recovery, Mercer Co., 2; Perry Township, Mongtomery Co., 1; Bay Point, Ottawa Co., 2; Payne, Paulding Co., 1; Aurora Pond, Portage Co., 75; Burgoon, Sandusky Co., 32; Fremont, Sandusky Co., 10; Bettsville, Seneca Co., 86; Cromers, Seneca Co., 10; Feaselburg, Seneca Co., 2; Lowell, Seneca Co., 2; Maple Grove, Seneca Co., 25; Old Fort, Seneca Co., 14; Pleasant Township, Seneca Co., 6; Longley, Wood Co., 7.

PENNSYLVANIA.—Drury Run, Clinton Co., 3 (U. S. Biological Surveys coll.); Pymatuning Lake, Crawford Co., 3; McKean, Erie Co., 4 (U. S. Biological Surveys coll.); Nazareth, Northampton Co., 1 (U. S. Biological Surveys coll.); Philadelphia, Philadelphia Co., 5.

WEST VIRGINIA.—Bickles Knob, Randolph Co., 18.

WISCONSIN.—Clarks Lake, Door Co., 3 (U. S. Biological Surveys coll.); Fish Creek, Door Co., 2 (U. S. Biological Surveys coll.); Sawyers Harbor, Door Co., 8 (Univ. Michigan Mus. Zool.); Florence, Florence Co., 1 (U. S. Biological Surveys coll.); Green Lake, Green Lake Co., 1 (U. S. Biological Surveys coll.); Mamie Lake, Vilas Co., 3 (U. S. Biological Surveys coll.).

So involved and complicated are the relationships of the races of *Blarina brevicauda*, that the following synopsis of the forms recognized by the present writers may prove useful.

1.—*Blarina brevicauda brevicauda* (Say). GIANT BLARINA

Sorex brevicaudus SAY, in Long's Exped. Rocky Mts., I, 1823, p. 164.

Type Locality.—Blair, Washington County, Nebraska.

Range.—The Missouri and Mississippi River valleys from northeastern Kansas and west central Illinois northwestward over Iowa, eastern Nebraska, eastern South Dakota, eastern North Dakota, western Minnesota, and western Wisconsin; smaller at northern edge of range; intergrading with *B. b. kirtlandi* in Illinois, Wisconsin, and northwestern Michigan.

Diagnosis.—The largest blarina, a massively proportioned shrew, with heavy, deeply-pigmented dentition.

Measurements.—Twelve topotypes from Blair, Nebraska, average: length, 134 mm.; tail, 25; hind foot, 17; weight: *specimens from Decorah, Iowa* (Univ. Michigan Mus. Zool.), average over 25 grams.

Specimens examined.—

Iowa.—Hillsboro, Henry Co., 2 (U. S. Biological Surveys coll.); Iowa City, Johnson Co., 3 (U. S. Biological Surveys coll.); Council Bluffs, Pottawattamie Co., 4 (U. S. Biological Surveys coll.); Tama, Tama Co., 2; Ireton, Sioux Co., 4 (Univ. Michigan Mus. Zool.); Decorah, Winneshiek Co., 6 (Univ. Michigan Mus. Zool.).

Minnesota.—Cass Lake, Cass Co., 1 (U. S. Biological Surveys coll.); Grand Marais, Cook Co., 6 (Univ. Michigan Mus. Zool.); Barrett, Grant Co., 5 (Univ. Michigan Mus. Zool.); La Crescent, Houston Co., 1 (U. S. Biological Surveys coll.); Elk River, Sherburne Co., 5 (U. S. Biological Surveys coll.); Towers, St. Louis Co., 4 (U. S. Biological Surveys coll.).

Nebraska.—Neligh, Antelope Co., 1 (U. S. Biological Surveys coll.); Kearney, Buffalo Co., 2 (U. S. Biological Surveys coll.); Valentine, Cherry Co., 1 (U. S. Biological Surveys coll.); Columbus, Platte Co., 3 (U. S. Biological Surveys coll.); Blair, Washington Co., 15 (topotypes, 1 in U. S. Biological Surveys coll.).

North Dakota.—Valley City, Barnes Co., 2 (U. S. Biological Surveys coll.); Oakes, Dickey Co., 3 (U. S. Biological Surveys coll.); Walhalla, Pembina Co., 1 (U. S. Biological Surveys coll.); Sweetwater, Ramsey Co., 2 (U. S. Biological Surveys coll.); Fairmount, Richland Co., 4 (U. S. Biological Surveys coll.); Wahpeton, Richland Co., 11 (U. S. Biological Surveys coll.); Turtle Mountain, Rolette Co., 1 (U. S. Biological Surveys coll.); Portland, Traill Co., 9 (U. S. Biological Surveys coll.).

Wisconsin.—Worden Township, Clark Co., 6 (5 in U. S. Biological Surveys coll.); Platteville, Grant Co., 5 (U. S. Biological Surveys coll.); Lynxville, Crawford Co., 2 (U. S. Biological Surveys coll.).

2.—*Blarina brevicauda kirtlandi* Bole and Moulthrop. Lake States Blarina

Type Locality.—Holden Arboretum, Lake and Geauga counties, Ohio.

Range.—From northwestern Michigan, eastern Wisconsin, and central Illinois, to West Virginia, eastern Pennsylvania, and southwestern New York; intergrading with *Blarina b. talpoides* over northeastern Pennsylvania and the greater part of New York State. Specimens from most of New York (Genesee, Madison, Essex, Westchester, and Suffolk counties) are more nearly referable to *B. b. talpoides.*

Diagnosis.—A medium sized blarina with strongly hooked maxillary projections and other distinctive cranial characters; proportionately the shortest and broadest footed race of the species.

Measurements.—One hundred and fifty topotypes average: length, 116 mm.; tail, 23; hind foot, 14; weight, 14.2 grams.

3.—*Blarina brevicauda talpoides* (Gapper). Ontario Blarina

Sorex talpoides Gapper, Zool. Journ., Vol. V, 1830, p. 202.

Type Locality.—Between York (Toronto) and Lake Simcoe, Ontario.

Range.—Ontario, and in less typical form, New York State, northeastern Pennsylvania, New Jersey, and southern New England from Connecticut and Cape Cod at least as far north as Sagadahoc County, Maine.

Diagnosis.—A large blarina, almost as large as *B. b. brevicauda* but much slenderer; strongly glossed with silver in fresh pelages; under parts noticeably paler than in *B. b. kirtlandi* or *B. b. brevicauda;* longer tailed than either of these forms; cranium more elevated; pigmentation of teeth greatly reduced as compared to *B. b. kirtlandi.*

Measurements.—Nineteen topotypes average: length, 127 mm.; tail, 26; hind foot, 16; weight, 20 grams.

Remarks.—Strictly typical *Blarina brevicauda talpoides* occurs only in Ontario. There is a progressive decrease in size towards the Atlantic coast of New Jersey and southern New England, coupled with a notable increase in the size of the external ear and degree of elevation of the cranium. If the southeastern stock from Long Island and coastal New Jersey should prove separable through further study, the name *Blarina brevicauda dekayi*[1] is available.

As here considered, *B. b. talpoides* is a variable race, all stocks of which are characterized by silvery under parts and lighter gray underfur than in the more western and southern races. Some New Hampshire and Vermont examples are confusingly close to *B. b. kirtlandi,* and all specimens from western New York and eastern Pennsylvania are somewhat intermediate between that form and topotypical material from Lake Simcoe, Ontario, particularly in the character of the hind foot.

Specimens examined.—

Ontario.—Haliburton, Haliburton Co., 2; Aurora, York Co., 19 (topotypes).

Quebec.—Bark Lake, Pontiac Co., 1.

Connecticut.—Cos Cob, Fairfield Co., 4 (U. S. Biological Surveys coll.); Stonington, New London Co., 2 (U. S. Biological Surveys coll.).

[1] *Sorex dekayi* Bachman (Cooper MS.), Journ. Acad. Nat. Sci. Philadelphia, Vol. VII, Part 2, 1837, p. 377.

MAINE.—Small Point Beach, Sagadahoc Co., 11.

MASSACHUSETTS.—Taunton, Bristol Co., 4; Essex, Essex Co., 6; Harvard, Middlesex Co., 3 (U. S. Biological Surveys coll.); Raynham, Plymouth Co., 3; Marshfield, Plymouth Co., 1 (U. S. Biological Surveys coll.); Wareham, Plymouth Co., 1.

NEW HAMPSHIRE.—Jackson, Carroll Co., 2; Jaffrey, Cheshire Co., 1; Pittsburg, Coos Co., 3; Mt. Moosilauke, Grafton Co., 1.

NEW JERSEY.—Mays Landing, Atlantic Co., 4; Princeton, Mercer Co., 2; Allaire, Monmouth Co., 2 (Univ. Michigan Mus. Zool.).

NEW YORK.—Giant Mountain, Essex Co., 1; St. Huberts, Essex Co., 15; Bergen Swamp, Genesee Co., 34; Elba, Genesee Co., 19; Peterboro, Madison Co., 2; Montauk Point, Suffolk Co., 23 (U.S. Biological Surveys coll.); Wading River, Suffolk Co., 16; Ossining, Westchester Co., 2.

VERMONT.—Wells River, Orange Co., 1.

4.—*Blarina brevicauda pallida* Smith. NOVA SCOTIA BLARINA

Blarina brevicauda pallida SMITH, Amer. Midl. Nat., Vol. XXIV, No. 1, July 31, 1940, p. 223.

Type Locality.—Wolfville, Kings County, Nova Scotia.

Range.—Nova Scotia and New Brunswick, and intergrading with *Blarina b. talpoides* in central and southwestern Maine.

Diagnosis.—A large pale gray blarina with a very long tail; showing accentuated *talpoides* characters, but the hind foot broader than in stocks of that race. Not all the Nova Scotia material seen by the writers shows measurements as great as a series of topotypes from Wolfville, Kings Co., Nova Scotia, but the tail is disproportionately long in all specimens.

Measurements.—Ten topotypes (Univ. Michigan Mus. Zool.) average: length, 126.6 mm.; tail, 29.1; hind foot, 16.5.

Specimens examined.—

NEW BRUNSWICK.—Scotch Lake, York Co., 3.

NOVA SCOTIA.—Lake Kedgemakooge, Annapolis Co., 8 (Univ. Michigan Mus. Zool.); James River, Antigonish Co., 1 (Univ. Michigan Mus. Zool.); Wolfville, Kings Co., 10 (topotypes, Univ. Michigan Mus. Zool.).

MAINE.—Ashland, Aroostook Co., 4; Caribou, Aroostook Co., 1 (Univ. Michigan Mus. Zool.); Mooselookmeguntic Lake, Franklin Co., 2 (*pallida-talpoides* intergrades).

5.—*Blarina brevicauda aloga* Bangs. MARTHAS VINEYARD BLARINA

Blarina brevicauda aloga BANGS, Proc. New Engl. Zoöl. Club, Vol. III, March 31, 1902, p. 76.

Type Locality.—West Tisbury, Dukes County, Massachusetts.

Range.—Confined to Marthas Vineyard Island, Massachusetts. Specimens showing characters approaching *B. b. aloga* are obtainable from the Cape Cod region of the mainland.

Diagnosis.—A medium sized blarina characterized by extremely pale under parts, reduced cranium, and small feet.

Measurements.—One topotype: length, 112 mm.; tail, 20.5; hind foot, 12.5.

Specimens examined.—

MASSACHUSETTS.—West Chop, Marthas Vineyard Island, Dukes County, 2.

6.—*Blarina brevicauda compacta* Bangs. NANTUCKET BLARINA

Blarina brevicauda compacta Proc. New Engl. Zoöl. Club, Vol. III, March 31, 1902, p. 77.

Type Locality.—Nantucket Island, Nantucket County, Massachusetts.

Range.—Nantucket Island, Massachusetts.

Diagnosis.—A small race in which the light color of the under parts has been carried up the flanks and onto the dorsal region.

7.—*Blarina brevicauda carolinensis* (Bachman). CAROLINA BLARINA

Sorex carolinensis BACHMAN, Journ. Acad. Nat. Sci. Philadelphia, Vol. VII, Part 2, 1837, p. 366.

Type Locality.—Eastern South Carolina.

Range.—As currently understood, *Blarina brevicauda carolinensis* ranges from Virginia to central Florida, and westward around the Appalachian Mountain system to Kentucky, Arkansas, and eastern Texas.

Diagnosis.—A very small, slaty black subspecies, so very much smaller than the other races thus far herein listed that detailed comparison is unnecessary. The writers have made no attempt to examine *carolinensis* stocks critically. The sepia tints frequently encountered in certain stocks are partly due to wear. The race badly needs careful study.

Measurements.—Thirteen topotypes from Eastern South Carolina (Beaufort County) average: length, 95 mm.; tail, 17; hind foot, 11.5; weight, 8.9 grams.

Specimens examined.—

FLORIDA.—Gainesville, Alachua Co., 4 (Univ. Michigan Mus. Zool.).
MARYLAND.—Cambridge, Dorchester Co., 2 (Univ. Michigan Mus. Zool.).
NORTH CAROLINA.—Currituck, Currituck Co., 1.
SOUTH CAROLINA.—Grays Hill, Beaufort Co., 13.

8.—*Blarina brevicauda peninsulae* Merriam. EVERGLADE BLARINA

Blarina carolinensis peninsulae MERRIAM, North Amer. Fauna, No. 10, December 31, 1895, p. 14.

Type Locality.—Miami River, Dade County, Florida.

Range.—"Peninsula of Florida, south of 28°" (Merriam).

Diagnosis.—"Similar to *carolinensis*, but with larger hind feet and more slaty coloration; molariform teeth larger" (Merriam). The writers of this report have seen no topotypes. Intergrades from northern Florida are no more slaty than *carolinensis* topotypes.

9.—*Blarina brevicauda hulophaga* Elliot. OKLAHOMA BLARINA

Blarina brevicauda hulophaga ELLIOT, Publ. Field Columbian Mus. No. 38, Zool. Ser., Vol. I; 1899, p. 287.

Type Locality.—Dougherty, Murray County, Oklahoma.

Range.—From Dougherty, Murray County, central southern Oklahoma, northeast at least as far as Tulsa, Oklahoma; probably occurs in suitable habitats throughout the eastern part of this State.

Diagnosis.—A small blarina, "uniform silvery gray in most lights, changing to light brown in others; under parts, paler hues of same colors . . . . becoming buff" (Elliot). Specimens (Univ. Michigan Mus. Zool.) from the vicinity of Tulsa, Oklahoma, show these characters. Much paler and larger footed than *B. b. carolinensis* and much smaller than *B. b. brevicauda* or *B. b. kirtlandi*.

Specimens examined.—

OKLAHOMA.—Mohawk Park, Tulsa Co., 2 (Univ. Michigan Mus. Zool.).

10.—*Blarina brevicauda plumbea* Davis. TEXAS COAST BLARINA

Blarina brevicauda plumbea DAVIS, Journ. Mamm., Vol. XXII, No. 3, August 14, 1941, p. 317.

Type Locality.—Aransas National Wildlife Refuge, Aransas County, Texas.

Range.—Known from only the Aransas National Wildlife Refuge in Aransas County, Texas, but presumably will be found to inhabit more extensive territory along the Texas coast.

Diagnosis.—"A small plumbeous-colored *Blarina* resembling *B. b. hulophaga*, but smaller and much paler; posterior border of palate highly arched anterodorsally . . ." (Davis). As described, the smallest blarina.

11.—*Blarina brevicauda churchi*, subsp. nov. Great Smoky Blarina

Type.—Adult female, skin and skull, No. 3640, Cleveland Museum of Natural History; August 20, 1910; Morton L. Church, original number (Church collection), 640.

Type Locality.—Roan Mountain, Mitchell County, North Carolina.

Range.—Presumably the higher portions of the Appalachian Mountains in western North Carolina and eastern Tennessee.

Diagnosis.—A very dark colored blarina of medium to large size, with proportionately the broadest skull of any of the races of *Blarina brevicauda.*

Color.—Summer pelage (the type). Upper parts very dark slaty gray, almost black, with little gloss; underfur dark slaty gray, darker than in other races of *Blarina*; under surface dark, only slightly lighter than upper parts; hairs of hind feet black; tail black above, grayish black below. There is a barely perceptible brownish cast to such gloss as the specimen shows.

Skull.—Very broad for a blarina, and of rather heavy build; rostrum broad, but the disproportionately broad cranium makes the rostrum appear narrow; cranium of medium depth; dentition well pigmented, with the fifth unicuspid (pm_1) regularly tipped with brown; unicuspid tooth row crowded, and the premaxillary portion of the rostrum shortened accordingly, as in *Blarina b. carolinensis.*

Measurements.—Type: total length, 125 mm.; tail, 28.5; hind foot, 16.5; condylobasal length, 20.2; mastoid breadth, 13.0; maxillary breadth, 8.0; palatal length, 8.8; tooth row, 8.8; width of foramen magnum, 2.9. *Type and 5 topotypes:* average, length, 118.4; tail, 26.1; hind foot, 15.3.

Remarks.—This new race is distinguishable from all other large blarinas by its very dark coloration, especially in the summer pelage, which is, however, but little darker than that of winter. It is further characterized by its broad cranium, which is as wide as in typical *B. b. brevicauda*, while the occipitonasal length of the latter form is usually from 2 to 4 millimeters greater. This relatively great mastoid breadth in proportion to the skull length is found to a somewhat less degree in *B. b. carolinensis* also, and it seems likely that *B. b. churchi* is but a giant mountain derivative of that subspecies, whose range almost completely surrounds that of the mountain animal. From *Blarina telmalestes* Merriam, *Blarina b. churchi* is distinguishable by numerous cranial details such as its greater mastoid breadth, more heavily pigmented dentition, and greater robustness of skull; it is furthermore more darkly colored, especially on the under surface. From *Blarina b. kirtlandi* it differs as indicated in the general statements made above, and in its spectacularly narrower foramen magnum. It has also a much longer tail.

The writers have the honor of naming this new race for Morton L. Church of Charlotte, North Carolina, long a student of mammals and a benefactor of this museum's mammal department.

Specimens examined.—

North Carolina.—Roan Mountain, Mitchell Co., 6 (type and 5 topotypes; including 1 in the U. S. Biological Surveys collection).

12.—*Blarina brevicauda hooperi*, subsp. nov. Long-tailed Blarina

Type.—Young adult female, skin and skull, No. 77380, University of Michigan Museum of Zoology; July 26, 1931; Victor H. Cahalane.

Type Locality.—Lyndon, Caledonia County, Vermont.

Range.—Known from only the type locality.

Diagnosis.—A small blarina characterized by its disproportionately large head and feet and its long tail, the last more than 23 percent of the total length, in these characters differing from all other forms of *Blarina*.

Color.—*Summer pelage* (the type). Upper parts smoke gray, with a noticeable brownish cast and very little gloss; under surface

lighter, more glossy; tail drab above and below; hind feet covered with dull grayish hairs, somewhat darker on outer surface of feet (inner edge as seen in prepared skin).

Skull (of type).—Short, broad, and low crowned; dentition heavy, with light pigmentation; maxillary projections very weakly developed, their points terminating in plane through hypocone and metastyle of m_2; second and third incisors well developed; pm_1 conspicuous but unpigmented.

Measurements.—Type: length, 105 mm.; tail, 26; hind foot, 14.5 (measurement taken from skin; field measurement given as 24, obviously an error); condylobasal length of skull, 22.5; interorbital constriction, 6.1; maxillary breadth, 7.7; mastoid breadth, 12.7; palatal length, 9.7; width of foramen magnum, 2.9; tooth row (from anterior border of i_2), 8.8. *Twelve topotypes and the type:* average, length, 104.1; tail, 24.1; hind foot, 14.6.

Remarks.—This new subspecies is a most astonishing departure from the general trend of the races of the genus *Blarina* to develop large northern forms. As represented by 13 specimens from the type locality (all in the collection of the Museum of Zoology at the University of Michigan), the race is utterly unique in its body proportions, but is considerably variable in size. The type is close to the average of the series, most of which are smaller than the type; 1 specimen is much larger (125 mm.). All agree in the peculiar smoky coloration, the large feet and tail, and in cranial characters.

Obviously, *Blarina brevicauda hooperi* is closely related to *Blarina brevicauda pallida* R. W. Smith, and is in effect a diminutive darker representative of that race. Its tail is relatively the longest of any race of *Blarina*, and its hind foot is, relatively, equally large. It is thus startlingly different from all *Blarina b. talpoides* stocks and is apparently unrelated to the more western races of the genus. Intergradation is not shown by any specimens seen by the writers, though certain series from eastern New Hampshire are apparently intermediates between *B. b. talpoides* and *B. b. pallida;* and a specimen from Wells River, Orange County, Vermont, is surprisingly close to *Blarina b. kirtlandi*, i.e., darker than either *hooperi* or *talpoides* and of different measurements.

In 1857 Baird named *Blarina angusticeps*[1] from Burlington,

[1]Rep. Explor. and Surv. R. R. Pac., Vol. VIII, 1857, p. 47.

Vermont, on the basis of what subsequently has proved to be a deformed skull. Since the cranial characters of the specimen are quite the opposite of broad-skulled *Blarina b. hooperi*, and since the specimens at hand from Giant Mountain, Essex County, New York (less than 30 miles from Burlington), are typical *B. b. talpoides*, the writers feel that the name *angusticeps* is not applicable to the northeastern Vermont race. Baird states (loc. cit.) that his specimen is externally identical with *Blarina talpoides*.

The writers take pleasure in naming the present form for Dr. Emmet T. Hooper of the Museum of Zoology at the University of Michigan, in recognition of his generosity in curtailing his own researches on *Blarina* in favor of those reported herein.

Specimens examined.—

VERMONT.—Lyndon, Caledonia Co., 13 (including the type; all in the collection of the University of Michigan Museum of Zoology).

13.—*Blarina telmalestes* Merriam. DISMAL SWAMP BLARINA

Blarina telmalestes MERRIAM, North American Fauna, No. 10, December 31, 1895, p. 15.

Type Locality.—Lake Drummond, Dismal Swamp, Norfolk County, Virginia.

Range.—The Dismal Swamp of extreme southeastern Virginia. This region is entirely surrounded, on the landward side, by the range of *Blarina b. carolinensis*, a form to which *Blarina telmalestes* bears almost no resemblance whatever.

Diagnosis.—A medium-sized blarina of dark, dull coloration, almost without gloss above, and lighter below; hind foot large and broad; tail rather long; skull excessively long and slender, as large as in topotypical *Blarina b. talpoides;* dentition with scant pigmentation. The general proportions and cranial characters of this 'species' suggest that it is closely related to *B. b. talpoides*, although differing in color and in other minor details.

Specimens examined.—

VIRGINIA.—Dismal Swamp, Norfolk Co., 30 (topotypes, U. S. Biological Surveys coll.).

14.—*Blarina costaricensis* J. A. Allen

Blarina costaricensis J. A. ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. III, Art. 14, April 17, 1891, p. 205.

Type Locality.—La Carpintera, Costa Rica; or upper Mississippi valley, United States.

Remarks.—This shrew was described in 1891 from a specimen reputedly from Costa Rica, obtained by George K. Cherrie, who lived in Iowa before he collected in Central America. The specimen apparently closely resembles *Blarina brevicauda brevicauda*, and caused a lively controversy between the describer and Dr. C. Hart Merriam, who believed the shrew to have come from Cherrie's home country[1]. The dispute is as yet unsettled, and might be finally ended only by the capture of another *Blarina* in Costa Rica. The writers have not seen Doctor Allen's type.

Myotis lucifugus lucifugus (LeConte)

LITTLE BROWN BAT

V[espertilio]. lucifugus LECONTE, in McMurtrie's Cuvier, Animal Kingdom, Vol. I, 1831, p. 431.

Type Locality.—Georgia; probably near Riceboro, Liberty County.

Despite the fact that only 1 Ohio specimen of *Myotis lucifugus* was seen by Miller and Allen for their revision of the genus[2], the large series of specimens collected since that date confirms their allocation of Ohio to the range of the subspecies *Myotis l. lucifugus.*

This bat is far less common in northern Ohio than several other species. In the southern part of the State it is, as is the case over most of its range, one of the 2 or 3 commonest species.

Ohio specimens examined.—

ADAMS COUNTY.—Ohio Brush Creek, 1.

ASHTABULA COUNTY.—Mechanicsville, 4; northwestern corner of Ashtabula County, 17.

CUYAHOGA COUNTY.—Cleveland, 1; Dover, 1.

DELAWARE COUNTY.—Lawrence Cave, 5.

FAIRFIELD COUNTY.—Lancaster, 3.

GEAUGA COUNTY.—Chesterland, 2.

HOCKING COUNTY.—Bat Cave, Laurel Township, 4.

LAKE COUNTY.—Mentor-on-the-Lake, 1; Willoughby, 1.

SENECA COUNTY.—Flat Rock, 3.

[1]See Merriam, North Amer. Fauna, No. 10, December 31, 1895, p. 10; also J. A. Allen, Bull. Amer. Mus. Nat. Hist., Vol. IX, March 11, 1897, p. 34.

[2]Bull. U. S. Nat. Mus., No. 144, April 18, 1928, p. 46.

Myotis keenii septentrionalis (Trouessart)

EASTERN LONG-EARED BAT

Vespertilio gryphus var. *septentrionalis* Trouessart, Cat. Mamm. Viv. et Foss., 1897, p. 131.

Type Locality.—Halifax, Nova Scotia.

This species has been collected but a few times in Ohio, yet the records indicate that its range is state wide. There is great variation in color of the specimens at hand. It is apparently the commonest species of woodland *Myotis* in northeastern Ohio, albeit not at all frequently met with. The species *Myotis lucifugus* tends to confine itself to open country and the vicinity of human habitations.

Ohio specimens examined.—

CLERMONT COUNTY.—Union Township, 1.
DELAWARE COUNTY.—Lawrence Cave, 1.
GEAUGA COUNTY.—Little Mountain, 4.
HOCKING COUNTY.—Bat Cave, Laurel Township, 1.
SENECA COUNTY.—Flat Rock, 2.

Myotis sodalis Miller and Allen

CAVE BAT

Myotis sodalis MILLER AND ALLEN, Bull. U. S. Nat. Mus., No. 144, April 18, 1928, p. 130.

Type Locality.—Wyandotte Cave, Harrison County, Indiana.

Robert Goslin of the Ohio State Museum was the first to collect *Myotis sodalis* in Ohio. The species is apparently very rare in the State, despite its abundance at its type locality near by and in Kentucky. It is known in Ohio from 2 counties only—Hocking and Highland. There is but a single specimen in the Cleveland Museum of Natural History, which was taken by Mr. Goslin and was received in exchange with the Ohio State Museum. This specimen is indistinguishable from a large series from War Eagle, Benton County, Arkansas, and from Kentucky specimens collected by Mr. Goslin for the Cleveland Museum's collection.

Ohio specimens examined.—

HOCKING COUNTY.—Goodhope Township, 1.

Pipistrellus subflavus subflavus (F. Cuvier)

SOUTHERN PIPISTRELLE

Vespertilio subflavus F. CUVIER, Nouv. Ann. Mus. Nat. Hist. Paris, Vol. I, 1832, p. 17.

Type Locality.—Eastern United States, probably Georgia.

All of Ohio lies within the area of intergradation between the 2 forms of *Pipistrellus subflavus* known to occur in the United States. As might be expected, there is enormous variability demonstrated in series from any one locality, particularly from the central part of the State. Specimens from the Cincinnati region and from as far east as Adams County along the Ohio River are nevertheless pale enough, in the aggregate, to be indistinguishable from specimens from North Carolina and Arkansas. Very few, however, are as pale as members of a series from Belleview, Marion County, Florida. Only from the extreme southwestern part of Ohio come specimens that can be definitely assigned to *Pipistrellus subflavus subflavus.*

Ohio specimens examined.—

ADAMS COUNTY.—Smoky Creek, 10.

CLERMONT COUNTY.—Union Township, 6.

HAMILTON COUNTY.—(No further locality) 10 (Woodrow Goodpaster coll.).

Pipistrellus subflavus obscurus Miller

NORTHERN PIPISTRELLE

Pipistrellus subflavus obscurus Miller, North Amer. Fauna, No. 13, October 16, 1897, p. 93.

Type Locality.—Lake George, Warren County, New York.

In the opinion of the writers most of the specimens of *Pipistrellus* from Ohio belong to this race. There is a well-marked tendency towards increasing darkness of coloration from the southwest towards the northeast. Robert Goslin, who was the first to recognize this fact, submitted specimens from Hocking and Seneca counties to Remington Kellogg who identified them as *P. s. obscurus.* These specimens are mostly in the Ohio State Museum. Subsequently, the Cleveland Museum of Natural History obtained from Mr. Goslin, series taken in Hocking and Fairfield counties and from Winston Jesseman others collected in Seneca County. None of these specimens is as dark as a series from Liberty Hill, New London County, Connecticut. The individuals

of a small series from Lawrence County, Ohio (in the southernmost tip of the State), are fully as dark, however, and isolated examples from other localities are still darker.

Twelve specimens from Liberty Hill, Connecticut, are fully as dark as examples from the type region in New York State. The writers have to date been unable to discover another record of the occurrence of the species in Connecticut. Two examples are of special interest in being melanistic, coal black in color, which, taken as they were soon after the great New England hurricane, caused considerable excitement among the collectors who obtained them. Examination of their skulls speedily revealed their true identity.

Ohio specimens examined.—

Belmont County.—Cat Run, 9.
Fairfield County.—Sugar Grove, 3.
Highland County.—Dry Cave, 1.
Hocking County.—Bat Cave, Laurel Township, 5.
Lawrence County.—Symmes Creek, 3.
Medina County.—Hinckley, 1.
Ross County.—Bainbridge, 4.
Sandusky County.—Fremont, 1.
Seneca County.—Flat Rock, 15; Goods Cave, 1 (Ohio State Museum).

Eptesicus fuscus fuscus (Beauvois)

Big Brown Bat

Vespertilio fuscus Beauvois, Cat. Raisonné Mus. Peale, Philadelphia, 1796, p. 18 (page 14 of the English edition by Peale and Beauvois).

Type Locality.—Philadelphia, Pennsylvania.

Big brown bats from Ohio are quite indistinguishable from examples from the middle Atlantic states. Throughout Ohio the species is very common, in many localities the commonest bat.

Ohio specimens examined.—

Adams County.—Manchester, 5; Smoky Creek, 1.
Cuyahoga County.—Cleveland, 8; Cleveland Heights, 1; North Chagrin Metropolitan Park, 5; Shaker Heights, 1.
Fairfield County.—Bern Township, 1.
Geauga County.—Chesterland, 1.
Hamilton County.—(No further locality) 3.
Hocking County.—Bat Cave, Laurel Township, 3; Clear Creek Cave, 1.
Medina County.—Hinckley, 1.
Portage County.—Geauga Lake, 3.
Ross County.—Bainbridge, 3.
Seneca County.—Bettsville, 3.

Lasionycteris noctivagans (LeConte)

SILVER-HAIRED BAT

Vespertilio noctivagans LECONTE, in McMurtrie's Cuvier, Animal Kingdom, Vol. I, 1831, p. 431.

Type Locality.—Eastern United States.

Despite the fact that there are but 4 specimens of this species in the Cleveland Museum's Ohio material, it is not uncommon in northeastern Ohio, and is frequently identifiable under street lights in the suburban portions of Cleveland. These 4 cannot be distinguished with certainty from a large series from western North Carolina or a small series from Saline Valley, Inyo County, California.

Ohio specimens examined.—

CUYAHOGA COUNTY.—Cleveland, 3; North Chagrin Metropolitan Park, 1.

Nycticeius humeralis (Rafinesque)

EVENING BAT

Vespertilio humeralis RAFINESQUE, Amer. Monthly Mag., Vol. III, 1818, p. 445.

Type Locality.—Kentucky.

Evening bats are known from Cincinnati[1], and from only a few records in the Ohio River valley, mostly near Cincinnati; but are very rare elsewhere in Ohio. Robert Goslin has taken the species in Fairfield County. Two of the Ohio specimens in the Cleveland Museum's collection are juveniles and hence are somewhat inadequate for comparison with other material at hand. Both are considerably darker than a specimen of the same age from Raleigh, North Carolina. An adult from Clermont County differs similarly from a specimen from Oak Lodge, Florida. Should this difference prove significant when larger series become available, the name of the Ohio animal would, in view of the type locality, probably remain the same.

Ohio specimens examined.—

CLERMONT COUNTY.—Union Township, 3.

[1]Goodpaster, Journ. Cincinnati Soc. Nat. Hist., Vol. XXII, No. 3, June, 1941, p. 42.

Lasiurus borealis borealis (Müller)

NORTHERN RED BAT

Vespertilio borealis MÜLLER, Natursyst., Suppl., 1776, p. 20.

Type Locality.—New York State.

All the red bats of the Cleveland Museum's Ohio collection are referable to *Lasiurus borealis borealis*, but a tendency towards *Lasiurus borealis seminola* is shown in specimens from the extreme southern parts of the State. This manifests itself in the slightly more brownish, less reddish coloration of the southern specimens.

Over much of Ohio the red bat is the commonest species of bat during the short time that it is in the State, that is, from May to September. Only in certain areas in southern Ohio is it regularly outnumbered by other forms (*Myotis* and *Pipistrellus*).

Ohio specimens examined.—

ADAMS COUNTY.—Smoky Creek, 3.

CLERMONT COUNTY.—Union Township, 4.

CUYAHOGA COUNTY.—Cleveland, 5; Lyndhurst, 1; North Chagrin Metropolitan Park, 1; Parma, 1.

GEAUGA COUNTY.—Chardon, 1.

LAKE COUNTY.—Mentor, 1.

LAWRENCE COUNTY.—Symmes Creek, 1.

ROSS COUNTY.—Bainbridge, 3.

SENECA COUNTY.—Bettsville, 8.

Lasiurus cinereus (Beauvois)

GREAT HOARY BAT

Vespertilio linereus (err. typ. for *cinereus*) BEAUVOIS, Cat. Raisonné Mus. Peale, Philadelphia, 1796, p. 18 (page 15 of the English edition by Peale and Beauvois).

Type Locality.—Philadelphia, Pennsylvania.

The great hoary bat is a rare species in Ohio, and is in most places probably a 'bat of passage'. The species has been mentioned, however, as seen in Geauga and other northern Ohio counties during the summer months. S. V. Wharram reports it for the same season in Ashtabula County[1]. Unfortunately these records are unsupported by specimens.

Ohio specimens examined.—

CUYAHOGA COUNTY.—Cleveland, 2; Lakewood, 1.

LORAIN COUNTY.—Lorain, 1.

[1]Unpublished manuscript in library of the Cleveland Museum of Natural History.

Euarctos americanus americanus (Pallas)

EASTERN BLACK BEAR

Ursus americanus PALLAS, Spicilegia Zoologica, Fasc. XIV, 1780, p. 5.

Type Locality.—Eastern North America.

The black bear is represented in the Ohio collections of the Cleveland Museum of Natural History by only skeletal remains recovered from Indian sites and peat bog excavations. It is, however, a matter of historic record that the species formerly occupied the entire State. In recent years it has been reintroduced into Scioto County, and the animal is of casual occurrence along the Ohio-Pennsylvania border.

Procyon lotor lotor (Linnaeus)

EASTERN RACCOON

[*Ursus*] *lotor* LINNAEUS, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 48.

Type Locality.—Eastern United States.

Raccoons were formerly found in all parts of Ohio, and are still locally common over most of the State. The Cleveland Museum of Natural History has no raccoons from outside of Ohio that are referable to the subspecies *Procyon l. lotor*, and the writers have not seen other northeastern specimens. On geographical grounds there is no reason to suspect that the Ohio animal is anything other than *Procyon lotor lotor*.

Ohio specimens examined.—

CUYAHOGA COUNTY.—Cleveland, 3; Dover, 1; Rocky River Metropolitan Park, 1.

LAKE COUNTY.—Kirtland Hills, 1.

PORTAGE COUNTY.—Geauga Lake, 2.

Bassariscus astutus subsp.

CACOMISTLE

The inclusion of a cacomistle in a list of mammals from Ohio is certain to excite critical comment. The record of the species in the State is most interesting. This record is to a large extent summarized in the Proceedings of the Cleveland Academy of Science,

p. 126, where the minutes of that organization's meeting of Jan. 30, 1857, are chronicled on page 126. This account mentions 5 specimens, of which all but 1 are definitely Ohio records, the assumption being that the fifth came also from Ohio. Two of the specimens are given definite locality records—Parma, Cuyahoga County, and Fairfield County. One of the specimens listed is mentioned as existing in the museum of the Kirtland Society of Natural Sciences in Cleveland. This individual has been seen by the authors.

After the dissolution of the Kirtland Society of Natural Sciences, its museum specimens, all mounted, were distributed, about the year 1880, to Case School of Applied Science and to Western Reserve University. In 1934 those at the former school were transferred to the Cleveland Museum of Natural History, the legal and financial heir of the Kirtland Society, which at an earlier date had absorbed the physical assets of the Cleveland Academy of Sciences. The specimens had suffered from neglect for many years at Case School, and were very dirty. The labels were, when provided, glued to the bottoms of the stands. One of these specimens was a *Bassariscus* and was labelled "Boston Ledges, O. 1871." The Boston Ledges are a rugged area of sandstone cliffs and ledges some 20 miles south of Cleveland. This is apparently the last specimen referred to in the citation given above.

This specimen was to have been cleaned and turned into a study skin, and the skull, contained in the mount, recovered. However, a number of the animals had fallen off their stands, and it was decided that these should be attended to first. While this was being done, an over zealous new employee of the Cleveland Museum's Building Department, discovering the dirty old mounts in the store-room in a separate building where they were being kept, burned the entire remaining lot. Gone in the holocaust were the *Bassariscus* in question; another *Bassariscus*, unlabeled, but probably the one that precipitated the account in the Proceedings of the Cleveland Academy of Science cited above; a wolf shot in 1810 on the present site of the Cleveland Museum of Natural History; a wolf from near the city of Quebec (topotypical of *Canis lupus lycaon* Schreber); a pine marten from Ohio; also other rarities and specimens of historical importance.

The writers feel that the evidence favors the probability that a form of *Bassariscus astutus* occurred very sparingly in Ohio until about 1875. It is possible that every one of the records resulted from the recapture of escaped captives, although it seems highly unlikely that 5 of these small carnivores should be trapped in the wild as a result of such escapes. At least 1 Ohio cacomistle record has definitely resulted from the capture of an escaped animal, as is shown by a statement made by Brayton[1]. Brayton's paper was written in 1882, however, and there is no means of determining whether or not he refers to 1 of the specimens mentioned in the Proceedings of the Cleveland Academy of Science, as he does not refer to that journal in this connection, and repeatedly gives evidence of his unfamiliarity with its contents.

Ohio specimens examined.—

Summit County.—Boston Ledges, 1.
Ohio.—(No further locality), 1.

Martes americana americana (Turton)

Eastern Marten

[*Mustela*] *americanus* Turton; Linnaeus, System of Nature, Vol. I, 1806, p. 60.

Type Locality.—Eastern North America.

Two specimens of pine marten, both taken in Ashtabula County, Ohio, were included in the collections of the Cleveland Museum's antecedent organizations. One of these specimens was destroyed in the manner alluded to in the foregoing account; the other, however, had fallen off its stand and hence was saved from the catastrophe. This specimen is now in the museum's collection (No. 7507). It is typical of the pine marten of Eastern Canada. The species has been extinct in Ohio for approximately 100 years. It was never common. Kirtland, writing in November, 1838[2], says "the pine weasel is admitted on the authority of Dr. Ward, who informs me that he has taken it in the vicinity of Chillicothe".

Ohio specimens examined.—

Ashtabula County.—(No further locality), 2.

[1]Rep. Geol. Surv. Ohio, Vol. IV, 1882, p. 43.
[2]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 176.

Martes pennanti pennanti (Erxleben)

EASTERN FISHER

[*Mustela*] *pennanti* ERXLEBEN, Syst. Regni Anim., Vol. I, 1777, p. 470.

Type Locality.—Eastern Canada.

Kirtland states[1] that 2 specimens of the fisher were taken in Ashtabula County in 1837. Two specimens also survived in the Kirtland Society and came to the Cleveland Museum of Natural History, where 1 was burned, and the other saved in the manner similar to the case outlined above. Unfortunately, the specimen saved had parted company with its data by the time it reached the Cleveland Museum, so that there is no means of ascertaining whether or not it is 1 of the specimens that Kirtland mentions. As Kirtland placed most of his specimens in the Cleveland Academy of Science's museum, its chances of being 1 of the last 2 fishers known to have been killed in Ohio are good.

Mustela cicognanii cicognanii Bonaparte

BONAPARTE WEASEL

M[*ustela*]. *cigognanii* [sic] BONAPARTE, Charlsworth's Mag. Nat. Hist., Vol. II, 1838, p. 37.

Type Locality.—Northeastern North America.

The Bonaparte weasel has been recorded in almost every list of Ohio mammals that appeared before 1900. As 'ermine' it was listed by Kirtland as "occasionally met with, but is mistaken for a *white weasel*". This state of confusion persisted for years. E. Raymond Hall went to some length to run down these records, and concluded, on the basis of existing specimens, that *Mustela c. cicognanii* should be stricken from the State list[2]. In November of 1937, however, George W. Jek, a young Cleveland taxidermist, collected a female at Pepper Pike, Cuyahoga County, Ohio. The specimen subsequently was given to the Cleveland Museum of Natural History. It is in winter pelage and is much smaller than any other female *M. c. cicognanii* that the writers have seen; it is no larger than a large male *Mustela rixosa*. The species must therefore be readmitted to the State list.

Ohio specimens examined.—

CUYAHOGA COUNTY.—Pepper Pike, 1.

[1]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 176.
[2]Amer. Midl. Nat., Vol. XVIII, March, 1937, p. 304.

Mustela rixosa allegheniensis (Rhoads)

ALLEGHENY LEAST WEASEL

Putorius allegheniensis RHOADS, Proc. Acad. Nat. Sci. Philadelphia, for 1900 (March, 1901), p. 751.

Type Locality.—Near Beallsville, Washington County, Pennsylvania.

The least weasel ranges over most if not all of Ohio. S. V. Wharram in his manuscript notes calls it rare in Ashtabula County. The series of specimens in the Cleveland Museum is rather uniform. In Ohio, this species regularly turns white in winter.

Ohio specimens examined.—

COLUMBIANA COUNTY.—Salem, 1.

CUYAHOGA COUNTY.—Chagrin Falls, 1; Cleveland Heights, 2; Lyndhurst, 1; North Olmsted, 1 (owl pellet record).

FRANKLIN COUNTY.—Columbus, 1.

HANCOCK COUNTY.—(No further locality known), 8.

LAKE COUNTY.—Holden Arboretum, 1; Kirtland Hills, 4.

PAULDING COUNTY.—Payne, 1.

PORTAGE COUNTY.—Aurora Pond, 1; Freedom Station, 5.

SENECA COUNTY.—Bettsville, 2.

SUMMIT COUNTY.—Akron, 1.

WOOD COUNTY.—Bowling Green, 1; Luckey, 1.

Mustela frenata noveboracensis (Emmons)

NEW YORK WEASEL

Putorius noveboracensis EMMONS, Report Quadrupeds Massachusetts, 1840, p. 45.

Type Locality.—Southern New York.

New York weasels from Ohio are identical with examples from various parts of New York State. The animal does not always turn white in winter in Ohio. Of 12 specimens taken between November 1 and April 1 in the Cleveland region, 5 are in the white pelage and 7 in the brown.

Ohio specimens examined.—

CUYAHOGA COUNTY.—Chagrin Falls, 1; Cleveland, 2; Newburgh, 1; North Chagrin Metropolitan Park, 2.

GEAUGA COUNTY.—Newbury, 1.

HURON COUNTY.—New London, 1.

LAKE COUNTY.—Kirtland, 2; Kirtland Hills, 2; Mentor, 1.

LORAIN COUNTY.—Elyria, 1.

PORTAGE COUNTY.—Freedom Station, 8.

SENECA COUNTY.—Bettsville, 1.

WAYNE COUNTY.—Wooster, 1.

Mustela vison mink Peale and Beauvois

COMMON MINK

Mustela mink PEALE AND BEAUVOIS, Cat. Peale's Mus., Philadelphia, 1796, p. 39.

Type Locality.—Maryland.

The writers have not yet had time critically to examine the minks in the Cleveland Museum collection. On geographical grounds, there is reason to suspect that the race occurring in western Ohio may be referable to *Mustela vison letifera* Hollister. The northeastern Ohio specimens listed below are all very dark, however, and are, on the basis of published descriptions, clearly referable to *Mustela vison mink.*

Ohio specimens examined.—

CUYAHOGA COUNTY.—Gates Mills, 1.
LAKE COUNTY.—Holden Arboretum, 1; Kirtland Hills, 3.
OHIO.—(No further locality,) 2.

Mustela putorius furo Linnaeus

FERRET

[*Mustela*] *furo* LINNAEUS, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 46.

Type Locality.—"Africa".

Ferrets have escaped from captivity repeatedly since Ohio was settled, and the species has become established in southern Geauga County and the adjacent portions of Cuyahoga County. Reports of the animal's existence as a wild species are occasionally brought in from this section, and the Cleveland Museum of Natural History has 1 wild-caught specimen. Details concerning the capture of the other example are not known.

Ohio specimens examined.—

CUYAHOGA COUNTY.—North Randall, 1.
GEAUGA COUNTY.—Bainbridge Township, 1.

Mephitis mephitis nigra (Peale and Beauvois)

COMMON BLACK SKUNK

Viverra nigra PEALE AND BEAUVOIS, Cat. Peale's Mus., Philadelphia, 1796, p. 37.

Type Locality.—Maryland.

The writers have made no effort to examine the Cleveland Museum's Ohio skunks critically, and are following the taxonomic judgment of E. Raymond Hall, as expressed in Publication 473 of the Carnegie Institution of Washington, 1936, p. 65.

Ohio specimens examined.—

Cuyahoga County.—Brook Park, 1; Cleveland, 2; Gates Mills, 1.
Erie County.—Kimball, 1.
Geauga County.—Stebbens Gulch, 1; Thompson Township, 1.
Lake County.—Holden Arboretum, 1; Mentor, 2; Willoughby, 1.
Lorain County.—Oberlin, 1.
Summit County.—Hudson, 8.

Taxidea taxus taxus (Schreber)

Common Badger

Ursus taxus Schreber, Säugthiere, Vol. III, 1778, p. 520.

Type Locality.—Labrador and Hudson Bay. It is very likely that Schreber's material came from the interior of Manitoba or Saskatchewan, rather than from Hudson Bay.

The Cleveland Museum of Natural History has a single specimen of badger from Ohio, which was supplied by E. L. Moseley of Bowling Green State College, who is the authority on the distribution of the badger in Ohio. The species was unknown to the earliest writers; Kirtland does not mention it, and Brayton believed the animal to have become extinct recently. There can be little doubt, however, that the species is, at the present time, actually increasing rather than disappearing. It is not uncommon locally in the northwestern part of the State[1].

The Cleveland Museum of Natural History has also skeletal fragments recovered from Indian village sites. Two such specimens were collected at Independence, Cuyahoga County, which are the easternmost records for the State.

Ohio specimens examined.—

Cuyahoga County.—Independence, 2 (skeletal fragments recovered from Indian village site).
Henry County.—Liberty Township, 1.

[The Cleveland Museum of Natural History has no Ohio specimens of either the wolverine, *Gulo luscus* (Linnaeus), or of the otter, *Lutra canadensis canadensis* (Schreber). Both

[1]Moseley, Journ. Mamm., Vol. XV, No. 2, May, 1934, pp. 156-158.

species formerly occupied most of the State, and the otter is still of rare occurrence in northeastern Ohio. An unlabeled wolverine in the Kirtland Society collection, burned, may have been from this State.]

Vulpes fulva fulva (Desmarest)

COMMON RED FOX

Canis fulvus DESMAREST, Mammalogie, Vol. I, 1820, p. 203.

Type Locality.—Virginia.

The career of the red fox has been a checkered one in Ohio. Kirtland says: "the red fox was unknown in this region of the country until the introduction of the white population, and is supposed by many not to have been originally a native of America. It has now become a common and troublesome inhabitant."[1] However, he goes on to state that the "cross fox was formerly killed on the Connecticut Western Reserve . . .". The species has continued in fluctuating numbers ever since Kirtland's time, but in recent years has become markedly rarer, particularly in the eastern part of the State, and is missing entirely from certain sections. Its numbers have been artificially bolstered in the Cleveland region through wholesale introductions by various hunt clubs. As the bulk of these animals were obtained from the middle Atlantic seaboard, particularly Virginia, there can be no doubt about the identification of the current northeastern Ohio red fox.

Ohio specimens examined.—

CUYAHOGA COUNTY.—Chagrin Falls, 1; Gates Mills, 2.
GEAUGA COUNTY.—South Newberry, 1.
LAKE COUNTY.—Kirtland, 1.
MEDINA COUNTY.—Hinckley, 1.
OHIO.—(No further locality), 1.

Urocyon cinereoargenteus cinereoargenteus (Schreber)

SOUTHERN GRAY FOX

Canis cinereo argenteus SCHREBER, Säugthiere, 1775, pl. XCII.

Type Locality.—Eastern North America.

The gray fox was, according to all the early writers, originally the only common fox in Ohio. It apparently had completely dis-

[1]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 176.

appeared from all except the wildest southeastern counties by 1850, and was very rare even there. Within the past quarter century, however, the species has made a most remarkable recovery, and is once again the common fox of the forested portions of the Allegheny plateau in eastern Ohio. It has made its reappearance in the Cleveland region only within the last 10 years.

The specimens listed below are identical with examples from North Carolina, West Virginia, and Connecticut.

Ohio specimens examined.—

Geauga County.—Chardon Township, 2; Little Mountain, 2.

Canis lupus nubilus Say

Middle Western Timber Wolf

Canis nubilus Say, Long's Exped. Rocky Mts., Vol. I, 1823, p. 169.

Type Locality.—Engineer Cantonment, near Blair, Washington County, Nebraska.

The wolf of Ohio is herein assigned to *Canis lupus nubilus* on the basis of the specimens mentioned above under the account of the burning of certain specimens from the Kirtland Society of Natural Sciences. The Cleveland specimen was a gray wolf, answering the description of *C. l. nubilus;* while the Quebec specimen[1] was much more reddish. Unfortunately, the specimens were destroyed before the skulls could be recovered and carefully examined.

Wolves were extirpated in Ohio during Kirtland's time; he, writing in 1838[2] said "the wolf is becoming very rare. A black species is said to have been a native of our state". The Cleveland Museum of Natural History has skeletal material recovered from bogs and Indian village sites.

Ohio specimens examined (destroyed).—

Cuyahoga County.—Cleveland, 1.

[Of the coyote (*Canis latrans latrans* Say), which is currently invading Ohio from Indiana, the Cleveland Museum of Natural History as yet has no specimens from Ohio.]

[1]A topotype; see Goldman, Journ. Mamm., Vol. XVIII, No. 1, February 14, 1937, pp. 37-45.

[2]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 176.

Felis catus Linnaeus

House Cat

[*Felis*] *catus* Linnaeus, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 42.

Type Locality.—Upsala, Sweden.

The familiar house cat is a feral animal in many parts of Ohio. The Cleveland Museum of Natural History has not taken pains to obtain series, but considerable skeletal material has found its way into the collection during the absorption of older collections.

Feral cats are commonly of two color types, either the familiar 'tiger' coloration or a dark, smoke gray phase. As a feral animal the house cat is confined largely to cities, but occurs in many rural districts as well.

[The Cleveland Museum of Natural History has no Ohio specimens whatever of the three native cats that formerly occupied the State—the Canada lynx (*Lynx canadensis canadensis* Kerr); the bobcat (*Lynx rufus rufus* [Schreber]); and the mountain lion or cougar (*Felis couguar* Kerr). There is reason to believe that a specimen of *Lynx canadensis*, without data, in the Cleveland Museum of Natural History (Kirtland Society collection) cannot possibly have come from Ohio.]

Marmota monax rufescens Howell

Rufescent Woodchuck

Marmota monax rufescens Howell, Proc. Biol. Soc. Washington, Vol. XXVII, February 2, 1914, p. 13.

Type Locality.—Elk River, Sherburne County, Minnesota.

The late Arthur H. Howell, author of the most recent revision of the American marmots[1], had for examination but 1 Ohio specimen, which came from Hicksville, near Toledo. This is a peculiar faunal area, its mammals generally differing considerably from those found elsewhere in the State. On the basis of what has already been discovered concerning the relationships of other Ohio species, it is logical to suppose that the woodchucks of Ohio would be far more closely related to more northern and western representatives of the species than to a form described from the

[1]North Amer. Fauna, No. 37, April 7, 1915, pp. 1-80; pls. I-XV.

middle Atlantic seaboard. Unfortunately the Cleveland Museum of Natural History has not yet obtained topotypical material of any race of *Marmota monax*, and in consequence the authors cannot effectively dispute Howell's assignment[1] of the western Ohio animal to *M. monax monax*. The authors are also hampered by the fact that all but 2 of the Cleveland Museum of Natural History's Ohio woodchucks were taken in the immediate vicinity of Cleveland.

Howell assigned the woodchucks of New York State to *M. m. rufescens*. Assuming that he was correct in so doing, the authors are compelled to add this form to the Ohio list, since a specimen from Orleans County, New York, is entirely indistinguishable from the northeastern Ohio series.

A specimen from Bettsville, Seneca County, is very peculiar and not strictly referable to any of the neighboring races of *Marmota monax*.

Specimens examined.—

Marmota monax rufescens

New York.—Orleans Co. (no further locality), 1.

Ohio.—Pymatuning Swamp, Ashtabula Co., 1; Chagrin Falls, Cuyahoga Co., 1; Cleveland, Cuyahoga Co., 2; North Chagrin Metropolitan Park, Cuyahoga Co., 1; Chardon Township, Geauga Co., 1; Thompson Township, Geauga Co., 1; Kirtland Hills, Lake Co., 4; Mentor, Lake Co., 1; Geauga Lake, Portage Co., 5; Mesopotamia Township, Trumbull Co., 1.

Marmota monax canadensis

Michigan.—Golden Lake, Iron Co., 1.

Marmota monax preblorum

Massachusetts.—Berkley, Bristol Co., 1; Taunton, Bristol Co., 2; Essex, Essex Co., 7; Plymouth, Plymouth Co., 1.

Marmota monax monax (Linnaeus)

Southern Woodchuck

[*Mus*] *monax* Linnaeus, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 60.

Type Locality.—Maryland.

A single juvenile from Clermont County, Ohio, must be referred to this subspecies, on the basis of available descriptions

[1]Loc. cit.

and comparison with juveniles of the same age from the northeastern part of the State.

Specimens examined.—

ARKANSAS.—Winslow, Washington Co., 1.
OHIO.—Union Township, Clermont Co., 1.

Citellus tridecem-lineatus tridecem-lineatus (Mitchill)

EASTERN STRIPED GROUND SQUIRREL

Sciurus tridecem-lineatus MITCHILL, Med. Repos., n. s., Vol. VI (XXI), 1821, p. 248.

Type Locality.—Central Minnesota[1].

The thirteen-lined ground squirrel is very local in its Ohio distribution, but it has been reported from the Indiana boundary eastward to Sandusky and Morrow counties[2]. It is also known as far east as Muskingum and Fairfield counties[3]. Ohio-caught specimens are considerably larger than the average for the subspecies *C. t. tridecem-lineatus*, but otherwise do not differ. This might be considered of sufficient importance to warrant their being described as a new race. The hiatus in the range as given by Howell in his "Revision of the North American Ground Squirrels"[4] does not exist[5].

Ohio specimens examined.—

ROSS COUNTY.—Bainbridge, 15; Mound City, 4.

Tamias striatus rufescens, subsp. nov.

OHIO RED CHIPMUNK

Type.—Young adult female, No. 9077, Cleveland Museum of Natural History; August 14, 1935; Philip N. Moulthrop.

Type Locality.—Chesterland Caves, Chester Township, Geauga County, Ohio.

Range.—The Allegheny plateau of northeastern Ohio at least as far south as Columbiana County, also east to Crawford County, Pennsylvania.

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[1]See Allen, Bull. Amer. Mus. Nat. Hist., Vol. VII, November 8, 1895, p. 338.
[2]See Enders, Occ. Papers Univ. Mich. Mus. Zool., No. 212, April 23, 1930, p. 12; also Preble, Journ. Mamm., Vol. XXIII, No. 1, February 14, 1942, p. 84.
[3]See Goslin, Journ. Mamm., Vol. XIV, No. 4, November 13, 1933, p. 369.
[4]North Amer. Fauna, No. 56, April [May 18], 1938, p. 108.
[5]See also Lyon, Amer. Midl. Nat., Vol. XVII, No. 1, February 27, 1936, p. 182.

Diagnosis.—A very short-tailed chipmunk of brilliant reddish coloration in summer pelage; similar to *Tamias striatus lysteri*, but darker and much more reddish both above and below.

Color.—Fresh summer pelage (August) (the type).—General coloration very reddish compared to comparable pelages of other races of *Tamias*. Rump reddish tawny, shading into the bright ochraceous buff (near ochraceous orange) of the flanks; feet near apricot buff; thighs like rump, verging toward color of flanks; light stripes of face bright ochraceous buff; dark stripes of face indistinct, near hazel, but heavily suffused with tawny; median dorsal stripe black-centered posteriorly for about two thirds of its length, rich reddish tawny at its anterior end and connecting with the tawny crown; black portion of stripe bordered throughout its length on both sides with narrow tawny bands that connect with the tawny rump; nose paler than crown, ochraceous buff suffused with black; ears tawny, fading to ochraceous orange at their anterior bases; lateral light stripes pale buff, suffused with tawny; lateral dark stripes black, the lower stripes shorter than the upper and heavily suffused with tawny and bright ochraceous buff hair at the ends; dorsal gray bands and shoulders suffused with buff; tail black above, each hair buff-tipped; tail ochraceous tawny below, bordered with buff-tipped black hairs; under parts clear white, the hairs white to their roots along the mid-line, elsewhere plumbeous basally. *Fresh winter pelage* (mid-October, No. 2591, C. M. N. H.). Much more grayish than the summer pelage, the reddish areas of the head and rump much restricted and suffused with blackish hairs, and the reddish areas brownish rather than tawny; tail with white-tipped hairs and light colored dorsal stripes nearer clear white, black stripes less invaded by buffy and tawny hairs.

Skull (type).—Short and broad for a chipmunk of the genus *Tamias*, with a shortened rostrum; molar teeth large; incisors narrow; brain case large.

Measurements.—Type: length, 230 mm.; tail, 72; hind foot, 33; greatest length of skull, 39.5; zygomatic breadth, 21.9; cranial breadth, 17.2; interorbital breadth, 10.8; postorbital breadth, 11.7; length of nasals, 13.5 *Ten specimens from near the type locality:* weight, average, 97.5 grams.

Remarks.—The writers have been unable to follow the late Arthur H. Howell's viewpoints with regard to the chipmunks of the genus *Tamias*[1]. As in the case of several other species of small mammals, the type localities of the 5 races heretofore recognized are peripherally situated within the range of the species. Howell attempted to assign the chipmunks of the southern Great Lakes region to several of these races, finally concluding that they belonged to the race *Tamias striatus fisheri* Howell which is topotypical at Ossining, Westchester County, New York. The only specimens that he had at hand from northeastern Ohio were series from Garrettsville and Ravenna in Portage County, both well within the region wherein typical *Tamias striatus rufescens* occurs.

A word on the subject of chipmunk molting is definitely in order here. Howell[2] says: "Apparently there is but one annual molt, which occurs usually in June or July. Very few molting specimens have been found in the material examined, but these indicate that the new hair appears in irregular patches over the whole dorsal surface . . .". Close critical study of the chipmunks in the Cleveland Museum of Natural History's collections, which were not available to Howell, indicates that there are dozens of specimens that show molting, and that there are 2 molts as well as 2 very different and very well-marked pelages—summer, and fresh winter. In *T. s. rufescens* the summer pelage is acquired during the latter part of June and the first weeks of July, as Howell indicates. Full summer pelage is confined to August and September. In the latter month the fall molt begins, first on the head, which changes from tawny to a buffy hazel color. By mid-October the fresh winter pelage is acquired, with the clear gray dorsal stripes and the loss of the brilliant rufescent coloration of the face, rump, ears, and flanks. The light stripes, buff in summer, become white. By late spring, when the winter pelage becomes faded and worn, a pelage is sometimes found which is astonishingly similar to the fresh summer pelage of *Tamias striatus griseus.* As the reddish summer fur is acquired, and again when it is lost, changes occur which make comparison with other races very difficult unless specimens of exactly comparable pelage are at

[1]North Amer. Fauna, No. 52, November, 1929, pp. 11-23.
[2]Loc. cit., p. 13.

hand. Howell apparently failed to recognize that the summer molt in topotypical *Tamias striatus lysteri* occurs in August, not June or July, and that it is of very short duration. He says[1] that the winter pelage of *T. s. lysteri* is not very different from the summer pelage, but the senior author, having seen the July-caught Ontario specimens in the Museum of Comparative Zoölogy that Howell uses to describe the summer pelage of that form, believes that these specimens are actually in worn winter pelage! By *Tamias striatus lysteri* the writers mean chipmunks of the genus *Tamias* from the type region around Georgian Bay only.

The race *T. s. rufescens* passes through a pelage in October which closely resembles *Tamias striatus fisheri* in fresh summer pelage, but even then is more reddish. At all seasons, the white stripes of *rufescens* are shorter than in *fisheri;* in the latter form they extend almost to the base of the tail. The median dorsal black stripe, which is black in *fisheri* for its entire length, is generally red for the anterior third of its length in *rufescens.* The rich reddish tones of *rufescens* in fresh summer pelage are unmatched in any other race, and set this subspecies apart as the most distinctive of all chipmunks, and certainly the most beautiful. It is much shorter-tailed than *fisheri,* the difference averaging 10 millimeters. It is also stouter skulled and smaller footed, but weighs more.

Compared to *T. s. lysteri, T. s. rufescens* is much darker and more reddish in all summer pelages; much darker and more grayish in winter pelages; also decidedly shorter tailed, the difference averaging 25 millimeters.

Comparable pelages of the other races are so different that close comparison is scarcely necessary. In worn winter pelages, *T. s. rufescens* bears a superficial resemblance to summer *T. s. griseus,* and some specimens may approach *T. s. venustus.* In no pelage does *rufescens* approach typical *Tamias s. striatus* or *Tamias striatus ohionensis,* which is diagnosed herein as new.

For the purpose of the description of this and the following race of chipmunks, the writers have used the Cleveland Museum of Natural History's topotypical series of *Tamias striatus lysteri* and *T. s. fisheri;* series from within a few miles of the type localities of *Tamias striatus striatus* and *T. s. venustus;* and a small series of

[1]Loc. cit., p. 18.

Tamias striatus griseus from southwestern Wisconsin. All these except the examples of *T. s. striatus* are in fresh summer pelage.

Specimens examined.—

Tamias striatus rufescens

New York.—Elba, Genesee Co., 1.

Ohio.—Mechanicsville, Ashtabula Co., 7; Lisbon, Columbiana Co., 1; Bratenahl, Cuyahoga Co., 3 (not typical); Brecksville Metropolitan Park, Cuyahoga Co., 2; Chagrin Falls, Cuyahoga Co., 2; Cleveland, Cuyahoga Co., 1; Cleveland Heights, Cuyahoga Co., 1; Gates Mills, Cuyahoga Co., 8; Lakewood, Cuyahoga Co., 3; North Chagrin Metropolitan Park, Cuyahoga Co., 20; North Olmsted, Cuyahoga Co., 4; Rocky River Metropolitan Park, Cuyahoga Co., 4 (not typical); South Euclid, Cuyahoga Co., 1; Auburn Corners, Geauga Co., 2; Burton Bog, Geauga Co., 7; Chesterland Caves, Geauga Co., 14 (including type); Little Mountain, Geauga Co., 95; Middlefield Township, Geauga Co., 4; Parkman Township, Geauga Co., 4; Shady Lake, Geauga Co., 1; Thompson Township, Geauga Co., 9; Welshfield, Geauga Co., 1; Holden Arboretum, Lake Co., 9; Kirtland Hills, Lake Co., 6; Leroy Township, Lake Co., 1; Mentor, Lake Co., 3; Pleasant Valley, Lake Co., 1; Mentor Marsh, Lake Co., 1; Wickliffe, Lake Co., 1; Willoughby, Lake Co., 2; Aurora Pond, Portage Co., 7; Geauga Lake, Portage Co., 8; Everett, Summit Co., 2; Twinsburg, Summit Co., 1.

Pennsylvania.—Pymatuning Lake, Crawford Co., 3.

Tamias striatus lysteri

New Brunswick.—Scotch Lake, York Co., 1.

Ontario.—South shore of Lake Nipissing, Parry Sound Co., 1; Haliburton, Peterborough Co., 2; Penetanguishene, Simcoe Co., 11 (topotypes); Mount Forest, Wellington Co., 5 (Mus. Comp. Zoöl.); Lansing, York Co., 1; Pottageville, York Co., 8.

Quebec.—Bark Lake, Pontiac Co., 2 (not typical).

Massachusetts.—Essex, Essex Co., 1; Carlisle, Middlesex Co., 1; Taunton, Plymouth Co., 1; Wareham, Plymouth Co., 1.

New Hampshire.—Jackson, Carroll Co., 6; Jaffrey, Cheshire Co., 1.

New York.—Lake Placid, Essex Co., 1; St. Huberts, Essex Co., 2.

Tamias striatus fisheri

New York.—Cohoes, Albany Co., 1; Ossining, Westchester Co., 10 (topotypes).

Tamias striatus griseus

Wisconsin.—Wausau, Marathon Co., 4.

Tamias striatus striatus

Indiana.—New Harmony, Posey Co., 1.

North Carolina.—Heywood Co. (no further locality), 3; Marshall, Madison Co., 14.

Tamias striatus venustus

Arkansas.—Winslow, Washington Co., 2.

Tamias striatus ohionensis, subsp. nov.

OHIO BROWN CHIPMUNK

Type.—Adult male, skin and skull, No. 16189, Cleveland Museum of Natural History; July 4, 1940; Woodrow Goodpaster.

Type Locality.—Cincinnati, Hamilton County, Ohio.

Range.—From northwestern and central Indiana to northeastern Kentucky and middle Ohio, east in the last mentioned State at least as far as Adams, Hocking, and Senaca counties.

Diagnosis.—A very dark, dull colored chipmunk with dark under parts, the darkest and dullest of the chipmunks of the genus *Tamias.*

Color.—Fresh summer pelage (the type). Rump between verona brown and dark chestnut brown, fading to hazel; sides of throat bright ochraceous buff; flanks dull buff; feet near clay color; pale dorsal stripes light ochraceous buff; median dorsal stripe black for three quarters of its length, terminating anteriorly in dark brown, which is faintly continuous with the hazel of the crown; shoulders and dorsal bands dark gray, heavily sprinkled with black hairs and faintly suffused with straw color; tail dull black above, with scattered buff-tipped hairs; tail ochraceous tawny below, bordered with blackish hairs thinly tipped with pale buff; under surface white, the hairs plumbeous at their bases all across the abdomen. *Winter pelage* (early April; No. 8809, C. M. N. H.). Very similar, but duller throughout, with the outer dorsal stripes heavily suffused with brown.

Skull (type).—Without distinctive features other than the very narrow incisors; slenderer than that of *T. s. rufescens* and with proportionally greater interorbital breadth; molar dentition rather robust; zygomata spreading less widely than in *T. s. rufescens* or *T. s. fisheri*; rostrum narrower than in *fisheri;* nasals shorter than in *fisheri,* terminating in front of the posterior premaxillary borders, instead of behind these borders as in *fisheri.*

Measurements.—Type: length, 247 mm.; tail, 92; hind foot, 34; greatest length of skull, 40.3; zygomatic breadth, 21.2; cranial breadth, 16.5; interorbital breadth, 10.6; postorbital breadth, 11.9; length of nasals, 13.6. Weights are not available for this form.

Remarks.—The chipmunks of western, southern, and central Ohio and of northern Indiana and southwestern Michigan caused

Arthur H. Howell a great deal of trouble. In his revision of the genus *Tamias*[1] he assigns certain chipmunks from the State of Indiana to *Tamias striatus striatus*, but the ranges of the various races as shown on the map on page 15 do not agree with statements made in the text. On the map, Indiana specimens are assigned to *Tamias striatus griseus*. Later, Howell apologizes for this state of confusion[2] and assigns all the chipmunks of this controversial area to *T. s. fisheri*. He also records *Tamias s. lysteri* from Hicksville, Ohio, near Toledo, a region from which the writers have seen no specimens. Since Howell failed to notice the differences between *Tamias s. rufescens* and true *T. s. fisheri*, there is small wonder that he eventually assigned the western Ohio animal to the latter race, which it certainly very closely resembles superficially. The taxonomy of the genus is simplified, however, by the recognition of the distinctive features of *Tamias striatus ohionensis*, since a very difficult geographical problem is thus avoided.

While *Tamias striatus ohionensis* is the darkest and dullest of the chipmunks of the genus *Tamias*, it resembles typical *T. s. striatus* in the degree of its darkness, but it is much less richly colored in all pelages. Compared to *T. s. striatus*, it would seem to be intergrading towards *T. s. griseus*, which doubtless caused some of Howell's difficulties. But it is so very much darker than *griseus* that close comparison on other points is scarcely necessary. Surprisingly, it is utterly unlike *T. s. rufescens* cranially as well as in color, and requires close comparison with only *T. s. fisheri*. Compared to this race it is darker and much duller; its whitish stripes are more buffy; the tail is much darker above as well as below; and the hairs of the tail are buff tipped rather than white tipped. The median dorsal stripe of *T. s. ohionensis* terminates anteriorly in dark brown, rather than in black as in *fisheri*.

Despite its resemblance to *fisheri*, *T. s. ohionensis* intergrades with *rufescens* through central northern Ohio, the area of intergradation beginning near Bettsville, Seneca County, and being nearly complete at the Cuyahoga River (Cleveland). Two specimens from Paulding County are typical *ohionensis*, as are all of the northern and central Indiana specimens that the senior writer has seen in the U. S. Biological Surveys collection. An example from

[1]North Amer. Fauna, No. 52, November, 1929, pp. 11-23.
[2]Journ. Mamm., Vol. XIII, No. 2, May 11, 1932, p. 166.

New Harmony, Posey County, however, is typical of *Tamias s. striatus* in everything except the color of the under side of the tail, which is near that of *ohionensis*. An individual from southern Adams County, Ohio, is also very close to *striatus*, but 2 from Bath County, Kentucky, are typical *T. s. ohionensis*. Howell assigned all his Kentucky specimens to *T. s. striatus* except 1 from the northeastern part of the State, which he called *fisheri*.

Specimens from the intergradation area between *ohionensis* and *rufescens* are very close to topotypical *fisheri* when the last mentioned is in fresh summer pelage; but the inclusion of *fisheri* in Ohio's list is unjustifiable on the basis of this alone, particularly since the skulls of these specimens show the characters of *rufescens*.

Specimens examined.—

INDIANA.—Miami Co., 2 (Mus. Comp. Zoöl.); Mount Ayr, Newton Co., 1 (U. S. Biological Surveys coll.); Hebron, Porter Co., 1 (U. S. Biological Surveys coll.).

KENTUCKY.—Bath Co., 2 (Cinc. Soc. Nat. Hist.).

OHIO.—Smoky Creek, Green Township, Adams Co., 2; Spring Grove Cemetery, Cincinnati, Hamilton Co., 14 (including the type); 7 miles east of Logan, Hocking Co., 1; Payne, Paulding Co., 2; Bettsville, Seneca Co., 4; Maple Grove, Seneca Co., 1; Wolf Creek, Seneca Co., 3.

Sciurus hudsonicus loquax Bangs

MIDDLE EASTERN RED SQUIRREL

Sciurus hudsonicus loquax BANGS, Proc. Biol. Soc. Washington, Vol. X, December 28, 1896, p. 161.

Type Locality.—Liberty Hill, New London County, Connecticut.

Comparison of Ohio red squirrels with topotypes of *Sciurus hudsonicus loquax* from Connecticut fails to reveal any trenchant differences. In comparable pelage (August) the Ohio animal seems to have a longer lateral black stripe, but even this character is not definitive. Furthermore, there is no difference in size. Specimens from northwestern Ohio seem somewhat darker in summer pelage than specimens from the northeastern part of the State, but there is little or no distinction in the winter pelages.

Red squirrels are still *Sciurus* to the writers, who do not believe that the possession of abnormally large Cowper's glands and lack of baculum constitute sufficient basis for the elevation of the

subgenus *Tamiasciurus* Trouessart to generic rank, particularly when the baculum is occasionally missing in individuals of other sciurine subgenera, notably in examples of the Central American species *Sciurus variegatoides.*

Ohio specimens examined.—

Ashtabula County.—Mechanicsville, 4.

Cuyahoga County.—Brecksville, 1; Chagrin Falls, 3; Cleveland, 1; Cleveland Heights, 1; Gates Mills, 20; Lakewood, 1; Lyndhurst, 1; North Chagrin Metropolitan Park, 5; North Olmsted, 4; Olmsted Falls, 1; Rocky River Metropolitan Park, 4; South Euclid, 3; Wickliffe, 2.

Geauga County.—Bradley Pond, 1; Chesterland, 7; Claridon, 1; Great South Bog, 2; Leroy, 1; Little Mountain, 14.

Hancock County.—Fostoria, 1.

Lake County.—Holden Arboretum, 4; Kirtland Hills, 15; Mentor, 1; Mentor Marsh, 1; Pleasant Valley, 1; Wickliffe, 1; Willoughby, 2.

Portage County.—Aurora Pond, 1; Freedom Station, 7.

Seneca County.—Bettsville, 3; Feaselburg, 1; Old Fort, 4; Pleasant Township, 1.

Summit County.—Everett, 1.

Sciurus carolinensis carolinensis Gmelin

Southern Gray Squirrel

[*Sciurus*] *carolinensis* Gmelin, Syst. Nat., Vol. I, Part 1, 1788, p. 148.

Type Locality.—"Carolina."

The Cleveland Museum of Natural History has extensive series of gray squirrels collected by Morton L. Church in Madison and Heywood counties, North Carolina, and 2 specimens from Beaufort County, South Carolina. All this material may be assumed to be topotypical. There is enough variation in it completely to engulf specimens from southern Ohio, particularly those specimens from the southern third of the State. Examples from Ross County show intergradation toward the subspecies *Sciurus carolinensis leucotis.*

Ohio specimens examined.—

Adams County.—Smoky Creek, 1.

Clermont County.—Union Township, 5.

Hamilton County.—(No further locality) 3.

Ross County.—Bainbridge, 3.

Sciurus carolinensis leucotis Gapper

NORTHERN GRAY SQUIRREL

Sciurus leucotis GAPPER, Zool. Journ. Vol. V, 1830, p. 206.

Type Locality.—Region between York (i. e., Toronto) and Lake Simcoe, Ontario.

The northern gray squirrel, in typical form, occupies the northern half of Ohio. Specimens in winter pelage from the Geauga plateau region are if anything more grayish than examples from New York and New England. Intergradation with *Sciurus c. carolinensis* takes place in a belt slightly south of the middle of the State.

Individuals in the black phase are frequently encountered in parts of Geauga County, especially where the species is not very common. Wherever the gray squirrel becomes very abundant the black color phase seems to disappear.

Ohio specimens examined.—

CUYAHOGA COUNTY.—North Chagrin Metropolitan Park, 2; Orange Township, 1.

GEAUGA COUNTY.—Little Mountain, 2; Middlefield, 1.

LAKE COUNTY.—Kirtland Hills, 6; Leroy, 1; Mentor, 1.

OTTAWA COUNTY.—Mud Creek, 1.

Sciurus niger rufiventer Geoffroy

MIDDLE WESTERN FOX SQUIRREL

Sciurus rufiventer GEOFFROY, Cat. Mamm. Mus. Nat. Hist. Nat. Paris, 1803, p. 176.

Type Locality.—Mississippi Valley, exact locality not known; according to Osgood[1] probably between southern Illinois and central Tennessee; but it appears to the writers that there are also excellent chances that the type specimen may have come from southern Ohio or southern Indiana.

Ohio fox squirrels are very uniformly colored, when seasonal pelage variations are taken into account. A slight darkening and graying of the pelage, noticeable in examples from the extreme southeastern portions of the State, may indicate a little approach to *Sciurus niger neglectus* which occupies most of West Virginia. The Ohio River may be taken as a convenient dividing line for

[1]Proc. Biol. Soc. Wash., Vol. XX, April 18, 1907, pp. 45-46.

the 2 races. Ohio specimens are not certainly distinguishable from examples at hand from Lake County, Tennessee, Washington County, Arkansas, and McLean County, Illinois. A specimen from Albany County, New York, apparently a record of considerable local interest, is likewise indistinguishable.

Ohio specimens examined.—

Adams County.—Smoky Creek, 2.

Cuyahoga County.—Chagrin Falls, 2; Cleveland, 5; Cleveland Heights, 7; Dover, 1; Gates Mills, 2; Lyndhurst, 2; North Chagrin Metropolitan Park, 1; North Olmsted, 1; South Euclid, 1; University Heights, 1.

Fairfield County.—Bern Township, 6.

Geauga County.—Chardon, 1; Montville, 1.

Lake County.—Kirtland Hills, 3; Mentor, 7; Pleasant Valley, 1; Wickliffe, 1; Willoughby, 1.

Lorain County.—Lorain, 1.

Ottawa County.—Mud Creek, 1.

Portage County.—Aurora Pond, 1; Earlville, 1.

Ross County.—Bainbridge, 1.

Sandusky County.—Fremont, 1.

Seneca County.—Pleasant Township, 1.

Glaucomys volans volans (Linnaeus)

Common Flying Squirrel

[*Mus*] *volans* Linnaeus, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 63.

Type Locality.—Virginia.

The common flying squirrel assumes a dark pelage in May and June which can easily be misinterpreted by students unaware of the changes occurring in any single individual within a year's time. With these changes in mind, comparable pelages of Ohio flying squirrels and those from elsewhere in the northeastern and middle western United States fail to show any significant differences. The species is equally static with regard to cranial characters.

Ohio flying squirrel populations are highly cyclical[1]. During peak years, which occur at 3 or 4 year intervals, the species becomes very abundant. Dr. Jared P. Kirtland recorded the species in his first State list[2].

[1]See Bole, Scient. Publ. Cleve. Mus. Nat. Hist., Vol. V, No. 4, December 28, 1939, p. 67.
[2]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 160.

Ohio specimens examined.—

Ashtabula County.—Mechanicsville, 5.

Clermont County.—Union Township, 1.

Cuyahoga County.—Bratenahl, 1; Brecksville, 1; Cleveland, 2; Euclid, 3; Gates Mills, 5; Lakewood, 1; North Chagrin Metropolitan Park, 2; Rocky River Metropolitan Park, 1.

Geauga County.—Auburn Corners, 2; Chesterland, 4; Great South Bog, 1; East Claridon, 2; Little Mountain, 26; Middlefield Township, 1; Shady Lake, 4.

Guernsey County.—4 miles south of Londonderry, 2.

Lake County.—Holden Arboretum, 6; Mentor Marsh, 8; South Kirtland, 1.

Portage County.—Aurora Pond, 2; Freedom Station, 1.

Seneca County.—Bettsville, 1; Pleasant Township, 1.

Stark County.—Canton, 1.

Dipodomys ordii richardsoni (Allen)

Richardson Kangaroo Rat

Dipodops richardsoni Allen, Bull. Amer. Mus. Nat. Hist., Vol. III, Art. 20, June 30, 1891, p. 277.

Type Locality.—On one of the sources of the Beaver River, Beaver County, Oklahoma.

The Richardson kangaroo rat has been introduced and is established on the shores of Lake Erie near Fairport, Lake County, Ohio. In a sand dune region not exceeding a square mile in area, the species is very abundant despite the local presence of *Rattus norvegicus* in great numbers. The locality is one from which snowy owls (*Nyctea nyctea*) are frequently reported in the winter months, so a number of interesting ecological relationships will possibly be discovered.

Ohio specimens examined.—

Lake County.—Richmond Beach, 2.

Castor canadensis canadensis Kuhl

Eastern Canadian Beaver

Castor canadensis Kuhl, Beiträge Zoologie, 1820, p. 64.

Type Locality.—Hudson Bay.

Beavers, once very abundant in Ohio, were exterminated by 1830. Now, 100 years later, the species is again reappearing in

northeastern Ohio, particularly along the Chagrin River. There is evidence that some of the individuals have reached Ohio by way of the shore of Lake Erie; others were deliberate introductions or have escaped from confinement. The species is very abundantly represented in remains from Indian village sites all over the State, and the Cleveland Museum of Natural History has several records from such sources. The single specimen listed below was run over by an automobile in 1939.

Ohio specimens examined.—

CUYAHOGA COUNTY.—South Chagrin Metropolitan Park, 1.

Reithrodontomys humulis merriami Allen

MERRIAM HARVEST MOUSE

Reithrodontomys merriami ALLEN, Bull. Amer. Mus. Nat. Hist., Vol. VII, Art. 3, May 21, 1895, p. 119.

Type Locality.—Austin Bayou, near Alvin, Brazoria County, Texas.

This harvest mouse is, to judge from the records, the rarest of Ohio's murine rodents. There are but 2 specimens in the Cleveland Museum of Natural History, both from Smoky Creek near Rome, Adams County. The species has been taken also in Fairfield County by Robert Goslin of the Ohio State Museum. It seems unlikely, on geographical and ecological grounds, that Ohio specimens should be referred to *Reithrodontomys h. merriami*, but to that race they were tentatively assigned on examination by A. H. Howell. The species is currently under study at the University of Michigan by Dr. Emmet Hooper, where the specimens listed below are on loan at the present time of writing.

Ohio specimens examined.—

ADAMS COUNTY.—Smoky Creek, 4 (including 2 skulls from barn owl pellets).

Peromyscus leucopus noveboracensis (Fischer)

COMMON DEER MOUSE

[*Mus sylvaticus*] δ *noveboracensis* FISCHER, Synopsis Mammalium, 1829, p. 318.

Type Locality.—New York.

Specimens of the common deer mouse from Ohio are, in comparable pelage, quite indistinguishable from examples from all parts of New York State. Compared to examples from northern New England, however, these same Ohio specimens are noticeably shorter tailed, indicating approach on the part of the New England specimens toward *Peromyscus leucopus caudatus* Smith.

The Cleveland Museum of Natural History has no topotypes of *Peromyscus leucopus leucopus* (Rafinesque), but as southwestern Ohio specimens seem as close to typical *P. l. noveboracensis* as those from the opposite corner of the State, this is no handicap for the purposes of this report.

The race *Peromyscus leucopus noveboracensis*, as it appears in Ohio, is the shortest-tailed stock of the species. The difference is at best very slight, but is of interest because almost all species of small mammals from Ohio show this variation, while New England and Nova Scotia examples of the same species are very long-tailed. Some species exhibit a corresponding tendency toward short, broad feet also. The environmental causes of these differences are totally unknown, and might provide the subject of some intensely interesting dietary and physiological researches. The tendency of all subspecific variations in Ohio species of small mammals to follow the same general trends is very marked.

Ohio specimens examined.—

Adams County.—Smoky Creek, 19.

Ashtabula County.—Andover, 5; Farnham, 8; Geneva, 1; Jefferson, 1; Lake Cardinal, 1; Mechanicsville, 35; Padanaram, 12.

Belmont County.—Cat Run, 37.

Brown County.—Ripley, 5.

Butler County.—Middletown, 5; Reily, 6.

Clermont County.—Chilo, 3; Union Township, 6.

Columbiana County.—Lisbon, 16.

Cuyahoga County.—Bedford, 12; Brecksville Metropolitan Park, 2; Chagrin Falls, 12; Dover, 3; Euclid, 9; Gates Mills, 109; Lyndhurst, 10; North Chagrin Metropolitan Park, 163; North Olmsted, 5; Rocky River Metropolitan Park, 31; South Euclid, 5; University Heights, 5.

Fairfield County.—Hocking Township, 11; Lancaster, 4.

Franklin County.—Columbus, 2.

Geauga County.—Auburn Corners, 5; Burton Bog, 24; Carvers Pond, 10; Chesterland Caves, 95; Lake Punderson, 5; Little Mountain, 298; Middlefield Township, 5; Munson Township, 3; Parkman, 6; Shady Lake, 15; Stebbens Gulch, 8; Thompson Township, 23.

Hamilton County.—Cincinnati, 2.

Hancock County.—Fostoria, 9.

Lake County.—Holden Arboretum, 130; Indian Point, 5; Kirtland, 3; Kirtland Hills, 19; Madison Township, 6; Mentor, 15; Mentor Marsh, 45; Richmond Beach, 12; Wickliffe, 9.

Lawrence County.—Symmes Creek, 2.

Lucas County.—Little Cedar Point, 3.

Mercer County.—Celina, 3; Fort Recovery, 9.

Montgomery County.—Perry Township, 3.

Ottawa County.—Bay Point, 5.

Paulding County.—Payne, 6.

Portage County.—Aurora Pond, 73.

Ross County.—Spargursville, 1.

Sandusky County.—Ballville, 6; Burgoon, 22; Fremont, 2.

Seneca County.—Bettsville, 63; Cromers, 8; Feaselburg, 3; Liberty Township, 4; Lowell, 2; Maple Grove, 12; Old Fort, 8; Pleasant Township, 6.

Summit County.—Northfield, 1; Peninsula, 1.

Wood County.—Longley, 13.

Peromyscus maniculatus bairdii (Kennicott)

Prairie White-footed Mouse

Mus bairdii Kennicott (Hoy and Kennicott MS.), Agric. Report, U. S. Patent Office, for 1856 (1857), p. 92.

Type Locality.—Bloomington, McLean County, Illinois.

The Cleveland Museum of Natural History's collectors were unable to capture any prairie white-footed mice at the type locality, and the writers have not seen any topotypes. The species has an enormous seasonal range of color, details of which are now being worked out by the junior author. A large series is on hand from Blair, Washington County, Nebraska, and material from Ohio in comparable pelage (September) is only very slightly darker and slightly shorter tailed. As eastern Nebraska specimens would naturally be expected to be near *Peromyscus maniculatus nebrascensis* (Coues), the writers, in the light of their present knowledge, feel that the Ohio form cannot be assigned to any other race than *P. m. bairdii.* Specimens from Genesee County, New York, first reported by Moulthrop[1], are quite indistinguishable from those from Ohio.

Prairie white-footed mice are becoming more abundant in Ohio but are strongly cyclical in their populations. Their range is state wide today, but the species is rare in the unglaciated portions of the southeast.

[1]Journ. Mamm., Vol. XIX, No. 4, November 14, 1938, p. 503.

Ohio specimens examined.—

Ashtabula County.—Geneva, 3.

Cuyahoga County.—Bedford, 2; Euclid, 1; Lyndhurst, 20; North Chagrin Metropolitan Park, 1; Pepper Pike, 1; Richmond Heights, 2; South Euclid, 3.

Fairfield County.—Pleasant Township, 1.

Geauga County.—Auburn Corners, 2; Shady Lake, 2.

Hancock County.—Fostoria, 9.

Lake County.—Fairport, 1; Holden Arboretum, 11; Madison Township, 1; Mentor, 18; Mentor Headlands, 3; Richmond Beach, 50.

Lucas County.—Little Cedar Point, 4.

Montgomery County.—Perry Township, 4.

Ottawa County.—Bay Point, 1.

Paulding County.—Payne, 6.

Portage County.—Aurora Pond, 6.

Sandusky County.—Ballville Township, 1; Burgoon, 1.

Seneca County.—Bettsville, 16; Maple Grove, 4; Pleasant Township, 1.

Wood County.—Longley, 14.

Neotoma magister Baird

Allegheny Wood Rat

Neotoma magister Baird, Rep. Explor. and Surv. R. R. Pac., Vol. VIII, 1857, p. 498.

Type Locality.—Carlisle, Cumberland County, Pennsylvania, or Harrisburg, Dauphin County, Pennsylvania.

For the use of the name *Neotoma magister* in place of the commonly accepted *Neotoma pennsylvanica* Stone, the type locality of which is South Mountain, Cumberland County, Pennsylvania, the reader is referred to E. L. Poole's recent discussion[1].

The Allegheny wood rat was first reported for Ohio by Dr. Jared P. Kirtland[2] as "Arvicola floridiana [sic]; Neotoma floridiana (Say and Ord)." That Doctor Kirtland's report referred to the Allegheny wood rat, then unknown as a distinct species, and not to *Neotoma floridana floridana* (Ord) cannot be doubted in view of the subsequent trapping records. Consequently, Hine's statement that his capture of a specimen of *Neotoma pennsylvanica* at Neotoma, Hocking County, constituted the first Ohio state record for the species, must be qualified[3].

Comparison of Ohio specimens with examples from the type locality of *Neotoma pennsylvanica* Stone fails to reveal any tren-

[1]Journ. Mamm., Vol. XXI, No. 3, August 14, 1940, p. 316.
[2]Second Ann. Rep. Geol. Surv. Ohio, 1838, pp. 161 and 177.
[3]Proc. Ohio Acad. Sci., Vol. VIII, Part 6, 1929, pp. 267-268.

chant differences. The species is very local in its Ohio distribution, being confined largely to limestone and sandstone cliffs at various scattered points on the unglaciated Allegheny plateau from Adams County northeastward to Hocking, Fairfield, and Washington counties. Doctor Kirtland's records for Ashland County have not been subjected to verification by recent collectors.

Ohio specimens examined.—

Adams County.—Smoky Creek, 3; Stout, 1.
Hocking County.—Clear Creek, 1.

[The Cleveland Museum of Natural History has so far failed to secure Ohio examples of *Oryzomys palustris palustris* (Harlan), which was reported somewhat hesitatingly by Kirtland[1] as *Arvicola amphibius;* by Brayton[2] on the basis of a specimen recovered from the stomach of a red-tailed hawk; and by Hine[3] on the basis of numerous skulls obtained by W. C. Mills from the Baum Village site near Chillicothe. It would appear that the species is extinct in Ohio today.]

Synaptomys cooperi cooperi Baird

Cooper Lemming Mouse

Synaptomys cooperi, Baird, Rep. Explor. and Surv. R. R. Pac., Vol. VIII, 1857, p. 558.

Type Locality.—Heretofore unknown; hereby fixed at Jackson, Carroll County, New Hampshire.

Baird, the original describer of *Synaptomys*, makes the following statement[4] concerning the type specimen: "No locality was assigned, but the animal is undoubtedly North American, probably from the New England States, or New York; possibly from Iowa or Minnesota." Despite this, subsequent authors with the exception of A. B. Howell, have for the most part assumed that William Cooper, who sent the type to Baird, collected somewhere near his home in Hoboken, New Jersey. Concerning these facts, Howell says[5]: "He [Baird] must have had some reason for making such a statement . . .". The present writers fully concur, especially

[1]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 161.
[2]Rep. Geol. Surv. Ohio, Vol. IV, 1882, p. 141.
[3]Ohio Nat., Vol. VI, No. 8, June, 1906, p. 550; ibid., Vol. X, No. 4, February, 1910, p. 71.
[4]Loc. cit., p. 556.
[5]North Amer. Fauna, No. 50, June 30, 1927, p. 13.

since William Cooper was a great traveler and is known to have received specimens from various collectors in different parts of the country. The writers, therefore, hereby fix the type locality at Jackson, New Hampshire, because adequate material from western New York does not seem to be available in the various museums of the country; because fixing the type locality in New Hampshire does the least possible damage to the existing taxonomic structure of *Synaptomys cooperi;* and because fixation of the type in Iowa or Minnesota would completely nullify the said existing structure.

The senior author has examined a topotype of *Synaptomys cooperi stonei* Rhoads in the U. S. Biological Surveys collection, from Mays Landing, New Jersey, and has also seen specimens in the same collection from Hyattsville, Maryland. In addition, there are, in the Cleveland Museum of Natural History, specimens from Marshall, Madison County, North Carolina, collected by Morton L. Church. From what the senior author has seen, he is forced to disagree with Mr. Howell concerning the identity of the lemmings of Ohio. Howell assigned the species as it occurs in Ohio to the subspecies *Synaptomys cooperi stonei*, on the basis of 2 specimens from Ravenna, Portage County, in the American Museum of Natural History. The present authors have not seen these 2 specimens, but have seen others from Portage County, and such are quite indistinguishable from examples of *S. c. cooperi* from northern New York and New Hampshire in the Cleveland Museum of Natural History, as are most of the more than 70 specimens from Ohio in this institution which came largely from the Geauga plateau of northeastern Ohio.

As these Ohio specimens represent all times of the year, the series shows molting and thus clarifies the molt behavior of the species. Howell did not have a series demonstrating this, which he regrets[1]. Individuals of *Synaptomys cooperi* from northeastern Ohio are in fresh summer pelage by mid-August, but not earlier. The fall molt occurs in October, and the fresh winter pelage—long, soft, and very much paler and more grayish than that of summer—is complete by the first week in November. As wear progresses, the grayishness gradually disappears, due to the loss of the glossy dark hair tips, and the consequent exposure of the light

[1]Loc. cit., p. 7.

brownish sections of the dorsal hairs. This wear progresses still farther, and by late May or early June the race assumes a bright ochraceous tawny cast that is utterly unlike any other pelage, and, because of its variability, is useless for comparative purposes. By the end of June the molt has again begun, and July specimens are of dark and seedy appearance. By mid-August all individuals, old and young alike, are in the familiar dark brownish pelage of summer. Subadults have a different pelage sequence; and in fresh pelage (July) they may closely approximate the fresh winter pelage of the adults.

In comparable pelage, examples from most of Ohio are indistinguishable from those of New York and New England; but it must be remembered that the northeastern Ohio *Synaptomys*, like several other species of small mammals from the same region, molts later than does the same species from other parts of its range. There are slight cranial variations in series, far too slight, however, to be of any particular significance. These variations, in size and dental characters, are in the direction of more western races of the species and not toward *Synaptomys c. stonei*. Certain series from central southern Ohio seem to show slightly more spreading zygomata and slightly darker and wider incisors, which can be interpreted as intergradation toward either *S. c. stonei* or toward *Synaptomys cooperi saturatus* herein described as a new subspecies. They are far closer to typical *S. c. cooperi*, however, and for this reason are referred to that race in this report.

Specimens examined.—

Ontario.—Ste. Rose, Laval Co., 6 (U. S. Biological Surveys coll.).

Quebec.—Godbout, Saguenay Co., 1 (U. S. Biological Surveys coll.).

Ohio.—Smoky Creek, Adams Co., 2; Brecksville, Cuyahoga Co., 1; Greenfield Township, Fairfield Co., 12; Auburn Corners, Geauga Co., 1; Chesterland Caves, Geauga Co., 16; Little Mountain, Geauga Co., 6; Munson Township, Geauga Co., 2; Thompson Township, Geauga Co., 1; Holden Arboretum, Lake Co., 13; Kipton, Lorain Co., 1 (owl pellet skull); Kirtland Hills, Lake Co., 1; Adams Mills, Muskingum Co., 1 (Ohio State Museum); Burgoon, Sandusky Co., 2; Bettsville, Seneca Co., 1.

New Hampshire.—Jackson, Carroll Co., 1; Pittsburg, Coos Co., 1.

New York.—Giant Mountain, Essex Co., 1; Wanakena, St. Lawrence Co., 1 (U. S. Blological Surveys coll.).

Vermont.—Mt. Mansfield, Lamouille Co., 1 (U. S. Biological Surveys coll.).

Synaptomys cooperi stonei Rhoads

STONE LEMMING MOUSE

Synaptomys stonei RHOADS, Amer. Nat., Vol. XXVII, No. 1, January, 1893, p. 53.

Type Locality.—Mays Landing, Atlantic County, New Jersey.

Two specimens in the Cleveland Museum of Natural History's collection of *Synaptomys* are referable to this race. Both of these specimens come from central eastern Ohio, 1 from Belmont County and 1 from Lisbon, Columbiana County. The Belmont County example is practically indistinguishable from examples of *S. c. stonei* from the Atlantic coastal plain. The Columbiana County specimen is very reddish in fresh summer pelage, but this can be interpreted as an intergradation between true *S. c. stonei* and *Synaptomys c. cooperi* as found in northeastern Ohio. The skulls of both specimens are typical of *stonei* in every detail and are at a glance distinguishable from those of Ohio examples of *cooperi*.

Specimens examined.—

OHIO.—Cat Run, Belmont Co., 1; Lisbon, Columbiana Co., 1.

MARYLAND.—Hyattsville, Prince George Co., 7 (U. S. Biological Surveys coll.).

NEW JERSEY.—Mays Landing, Atlantic Co., 1 (topotype in U. S. Biological Surveys coll.).

NORTH CAROLINA.—Marshall, Madison Co., 4; Roan Mountain, Mitchell Co., 2 (not typical).

Synaptomys cooperi saturatus, subsp. nov.

ILLINOIS LEMMING MOUSE

Type.—Adult male, skin and skull, No. 13450, Cleveland Museum of Natural History; September 2, 1938; Winston C. Jesseman.

Type Locality.—Bloomington, McLean County, Illinois.

Range.—Illinois and Indiana, west into eastern Missouri, and east to extreme western Ohio.

Diagnosis.—Large, and very dark colored, with a very long, narrow skull; the darkest of the races of *Synaptomys cooperi*.

Color.—Summer pelage (the type). Upper parts near sayal brown, very heavily suffused with black, changing on the crown

and nose to grizzled hair brown and silvery gray; sides very slightly paler than the back; underfur of upper surface dark slate color; lower parts near gull gray, glossy, and with slate gray underfur showing through; a patch of whitish hairs, whitish to the roots, on the throat; cheeks like under surface; sides of face and ears like crown and nose; feet and tail drab above, the tail whitish below, and the heels of the hind feet with a tuft of blackish hairs.

Skull (of type).—Very long and slender, with lengthened narrow rostrum equipped with massive incisors nearly 2 mm. in width; incisors dark ochraceous orange in color; maxillary tooth row short, and the individual teeth very small for so long a skull. The skull is of the length of that of *Synaptomys cooperi gossii* (Coues) but is of the general proportions of that of *S. c. stonei.*

Measurements.—Type: length, 127 mm.; tail, 14; hind foot, 19; condylobasilar length of skull, 24.4; length of rostrum, 6.1; breadth of rostrum, 5.6; interorbital constriction, 3.5; zygomatic breadth, 16.2; lambdoidal width of cranium, 12.7; incisive foramina, 4.9.

Remarks.—This new race, *Synaptomys cooperi saturatus,* is intermediate in its cranial characters between *S. c. cooperi* and *S. c. gossii;* but as it is near *gossii* in length of skull while retaining the general breadth of measurements of *cooperi,* it has the outward appearance of *S. c. stonei,* from which, however, it differs sharply in many cranial details. These are precisely the cranial characters pointed out by Howell[1] for certain specimens from eastern Missouri and Illinois. As the range of *cooperi* lies between that of *stonei* and *saturatus* in Ohio, a fact that Howell could not have fully appreciated since he had for examination but 2 specimens from the State, it is not surprising that he assigned all his Indiana specimens to *stonei.* This is all the more plausible when it is appreciated that Howell wisely refrained from using color as a primary indication of subspecific affinities, since he had insufficient specimens from any one locality to demonstrate the sequence of molt.

In color *S. c. saturatus* is very much the darkest of the races of *Synaptomys cooperi* and is on this basis alone easily separable in all pelages. There is very little difference in the degree of dark-

[1]North Amer. Fauna, No. 50, June 30, 1927, p. 19.

ness between winter and summer pelages, but the winter is more grayish. The winter pelage is *much* darker than in typical *cooperi*, and in all pelages *saturatus* is darker than comparable *gossii*. Compared to *S. c. stonei* as considered in this report, the difference becomes extreme. Also, the tail of *saturatus* is very much abbreviated and its feet proportionately short as well as very broad, in these respects being extreme for the species. It thus follows the general pattern of subspecific variation already demonstrated in many other Ohio mammals. As an Ohio animal it can scarcely be said to occur in typical form, since the skulls and feet of the examples from this State are obviously smaller than those of specimens from farther west. The northwestern Ohio representatives are, however, very dark colored, the darkest of those examined. The specimens listed from the region around Cincinnati, Ohio, are somewhat atypical and represent intergradation between *S. c. cooperi* and *S. c. saturatus*. The specimens from Horseshoe Lake, Missouri, are paler than the type, but the Callaway County specimen is fully as dark as the type.

Specimens examined.—

Illinois.—Bloomington, McLean Co., 2 (including the type).

Indiana.—Brookville, Franklin Co., 6 (U. S. Biological Surveys coll.); Bicknell, Knox Co., 1 (U. S. Biological Surveys coll.); Bascom, Ohio Co., 8 (U. S. Biological Surveys coll.).

Missouri.—East Columbia, Callaway Co., 1 (U. S. Biological Surveys coll.); Horseshoe Lake (near St. Louis), 16 (U. S. Biological Surveys coll.).

Ohio.—Chilo, Clermont Co., 1; Evansport, Defiance Co., 1 (owl pellet skull); Hamilton Co. (no further locality), 2; Coldwater, Mercer Co., 1; Fort Recovery, Mercer Co., 1; Antwerp, Paulding Co., 6 (owl pellet skulls).

Clethrionomys gapperi paludicola Doutt

Pymatuning Red-backed Vole

Clethrionomys gapperi paludicola Doutt, Proc. Biol. Soc. Wash., Vol. LIV, December 8, 1941, p. 162.

Type Locality.—Four miles west of Linesville, Crawford County, Pennsylvania.

The present authors had the description of this race of red-backed vole in manuscript when Mr. Doutt's paper appeared. His description of the new form is so nearly identical with ours that his work may be said to stand partially already verified! Linesville,

Pennsylvania, is only about 6 miles from Padanaram, Ohio, which the present writers had selected as their type locality, and the type of *C. g. paludicola* was taken actually 4 miles west of Linesville, i. e., at the present site of Pymatuning Lake, the creation of which destroyed the forests inhabited by this vole. Padanaram, on the Ohio side, is likewise at the lake edge.

This subspecies formerly occupied the great swampy hemlock forest of Pymatuning in Ashtabula County, Ohio, and Crawford County, Pennsylvania, and was known from also the valley of Conneaut Creek, whence came the specimen first reported from Ohio[1]. Subsequent trapping at this station has proved unfruitful to date, and red-backed voles are perhaps the easiest of all small mammals to trap. At Pymatuning, devastating changes have almost certainly eliminated the species on the Ohio side of the reservoir, since the actual site of the capture of the specimens listed below is now under water. Surrounding forests have been almost completely lumbered, and it is very doubtful that the species, as a member of the Ohio fauna, could have survived the droughts of the past decade.

The present authors cannot concur with Doutt in his remarks concerning the possibility that 2 species of *Clethrionomys* occupy common ground in West Virginia, Pennsylvania, and Maryland. The genus *Clethrionomys* has gone unrevised in recent years, and its species *gapperi* is highly variable. On the basis of studies conducted by the authors in connection with their stillborn description of a new race from Ohio, they are forced to the conclusion that the name *Clethrionomys gapperi gapperi* may ultimately be restricted to eastern Canadian specimens of the red-backed vole. Examples of *C. g. paludicola* from its type region are much nearer to *C. g. gapperi* from Pontiac County, Quebec, than they are to any stock of this species that the writers have seen from the United States side of the St. Lawrence River. Pending revision of the genus, New York State specimens cannot be properly allocated, and the same is obviously true of specimens from central Pennsylvania and West Virginia. The fact that *Clethrionomys gapperi gapperi* (Vigors) has disappeared from its type region between Toronto and Lake Simcoe, Ontario, will not give any assistance to future revisers of the genus.

[1]See Enders, Journ. Mamm., Vol. IX, No. 2, May 9, 1928, p. 155.

Specimens examined.—

Clethrionomys gapperi paludicola Doutt

OHIO.—Padanaram, Ashtabula Co., 5.

Clethrionomys gapperi rhoadsii (Stone)

NEW JERSEY.—Mays Landing, Atlantic Co., 4; Lakehurst, Ocean Co., 3.

Clethrionomys gapperi maurus Kellogg

KENTUCKY.—Lynch, Harlan Co., 4 (topotypes in U. S. Nat. Mus.).

Clethrionomys gapperi carolinensis (Merriam)

NORTH CAROLINA.—Roan Mountain, Mitchell Co., 7 (topotypes).

Clethrionomys gapperi ochraceus (Bangs)

NEW BRUNSWICK.—Queensbury, York Co., 1; Scotch Lake, York Co., 5.

NOVA SCOTIA.—Seal Island, Guysborough Co., 4 (not typical).

MAINE.—Ashland, Aroostook Co., 3; Mooselookmeguntic Lake, Franklin Co., 7.

MASSACHUSETTS.—North Reheboth, Bristol Co., 1; Raynham, Bristol Co., 2; Taunton, Bristol Co., 5; Essex, Essex Co., 1; Wareham, Plymouth Co., 2.

NEW HAMPSHIRE.—Jackson, Carroll Co., 8; Pittsburg, Coos Co., 4.

NEW YORK.—Giant Mountain, Essex Co., 5 (near *C. g. gapperi*); St. Huberts (Keene Heights), Essex Co., 14 (near *C. g. gapperi*).

VERMONT.—Ryegate, Caledonia Co., 1.

Clethrionomys gapperi gapperi (Vigors)

QUEBEC.—Bark Lake, Pontiac Co., 8.

MICHIGAN.—Golden Lake, Iron Co., 3; 12 miles north of Newberry, Luce Co., 3.

NEW YORK.—Peterboro, Madison Co., 17 (not typical).

Clethrionomys gapperi brevicaudus (Merriam)

SOUTH DAKOTA.—Bull Springs, Custer Co., 8.

Clethrionomys gapperi galei (Merriam)

WYOMING.—Gros Ventre Mountains, Sublette Co., 1; Hoback Mountains, Sublette Co., 8; Pinedale, Sublette Co., 1.

Microtus pennsylvanicus pennsylvanicus (Ord)

EASTERN MEADOW VOLE

Mus pennsylvanica ORD, Guthrie's Geography, 2nd Amer. ed., Vol. II, 1815, p. 292.

Type Locality.—Meadows below Philadelphia, Pennsylvania.

The ubiquitous meadow or field vole is found in all parts of Ohio, but becomes rather local in its distribution on the unglaciated Allegheny plateau of the southeastern part of the State. Elsewhere

it is one of the most abundant mammals, populations as high as 50 per acre of rich meadowland being of frequent occurrence.

Ohio meadow voles are shorter tailed and broader footed than most topotypical examples, but the differences are slight. There seem to be no significant differences in coloration or cranial characters. The weights of Ohio specimens seem to be somewhat under those of topotypes. This character is unreliable, however, in a species the weights of whose individuals are so strongly governed by the age of the specimens.

It is significant that the 2 commonest species of Ohio mice, the meadow vole and the deer mouse, and the commonest shrew, the lake states blarina, are the least variable of all Ohio small mammals. It may truly be said that with the exception noted above for the vole, these 3 species cover the State at all times in huge, continuous colonies within their respective habitats. All the other species of these 2 groups become rare or absent in certain parts of the State during their cyclical minima, and their populations become discontinuous. In the rarer forms, the species never attain general distribution even during their maximum populations, and many of these occur in isolated colonies, sometimes widely separated. It is these rarer forms that show the greatest taxonomic variability.

Ohio specimens examined.—

Adams County.—Smoky Creek, Green Township, 2.

Allen County.—Bluffton, 1.

Ashtabula County.—Andover, 2; Farnham, 9 (1 in Ohio State Museum); Lake Cardinal, 2; Mechanicsville, 11; Padanaram, 6.

Belmont County.—Cat Run, 1.

Brown County.—Ripley, 1.

Butler County.—Oxford, 3.

Clermont County.—Union Township, 3.

Cuyahoga County.—Bedford, 6; Bratenahl, 1; Chagrin Falls, 25; Cleveland, 8; Cleveland Heights, 16; Dover, 2; Euclid, 10; Gates Mills, 18; Lakewood, 5; Lyndhurst, 176; North Chagrin Metropolitan Park, 22; North Olmsted, 3; Pepper Pike, 2; Richmond Heights, 1; Rocky River Metropolitan Park, 50; University Heights, 38.

Fairfield County.—Berne Township, 20; Greenfield Township, 5; Hocking Township, 9 (1 in Ohio State Museum); Lancaster, 1 (Ohio State Museum).

Franklin County.—Columbus, 4 (Ohio State Museum).

Geauga County.—Auburn Corners, 2; Carvers Pond, 7; Chesterland

Caves, 19; Great South Bog, 8; Munson Township, 6; Punderson Lake, 1; Shady Lake, 10; Thompson Township, 2.

Hamilton County.—Cincinnati, 9.

Hancock County.—Fostoria, 12.

Lake County.—Holden Arboretum, 65; Kirtland Hills, 15; Leroy Township, 1; Little Mountain, 8; Madison Township, 4; Mentor, 25; Mentor Marsh, 30; Richmond Beach, 24; Wickliffe, 5.

Lawrence County.—Symmes Creek, 5.

Licking County.—Flint Ridge, 1 (Ohio State Museum).

Lorain County.—Elyria, 1.

Lucas County.—Little Cedar Point, 3.

Mahoning County.—Fllsworth, 1 (Ohio State Museum).

Mercer County.—Celina, 3; Fort Recovery, 8.

Montgomery County.—Perry Township, 3.

Ottawa County.—Bay Point, 3.

Paulding County.—Payne, 1.

Portage County.—Aurora Pond, 254.

Sandusky County.—Burgoon, 24; Fremont, 8.

Seneca County.—Bettsville, 65; Five Points, 1; Iler, 1; Maple Grove, 10; Old Fort, 2; Tiffin, 1 (Ohio State Museum).

Shelby County.—(No further locality), 5 (Ohio State Museum).

Summit County.—Northfield, 2.

Microtus ochrogaster ohionensis, subsp. nov.

Ohio Prairie Vole

Type.—Adult female, skin and skull, No. 10430, Cleveland Museum of Natural History; August 26, 1936; Scott R. Inkley.

Type Locality.—Symmes Creek, 2 miles north of Chesapeake, Lawrence County, Ohio.

Range.—Central southern and southwestern Ohio, north to central western Ohio (Shelby County), and in less typical form west to central eastern Indiana (Jay County).

Diagnosis.—The only race of *Microtus ochrogaster* that is not buff-bellied; further characterized by its dark upper surface and short, broad skull with very short tooth row and narrow molars; size larger than *Microtus ochrogaster ochrogaster*, with shorter feet, and smaller, broader skull.

Color.—Summer pelage (the type). Upper parts of finely mixed coloration, the light colored hairs near hazel, the darker ones black, the combined effect being very dark bister; black hairs predominating on nose, crown, back, and rump, the rump very much darker than rest of upper surface; flanks and sides of nose paler, with less admixture of black hairs; underfur of upper parts

dark neutral gray; ears colored like crown; tail like rump above, whitish below except near tip; superior surface of feet dark, colored like rump; under parts silvery gray, the dark gray underfur showing through.

Skull (the type).—Short and broad, with short nasals terminating in a plane anterior to the most anterior orbital border; tooth row short; teeth very narrow; interpterygoid fossa very narrow; tympanic bullae much flattened; cranium proportionately large and well inflated.

Measurements.—Type: length, 149 mm.; tail, 29.5; hind foot, 18; greatest (condylonasal) length of skull, 25.5; basilar length, 22.3; zygomatic breadth, 14.8; interorbital constriction, 4.3; length of nasals, 7.1; palatal length, 11.5; postpalatal length, 10.9; incisive foramina, 4.8; diastema, 7.3; maxillary tooth row, 5.9; width of m_1, 1.0. *Type and 4 paratypes:* average, length, 151; tail, 32; hind foot, 18.

Remarks.—This new subspecies is exceedingly well marked, and is easily separable on the basis of color alone. It is the only race of *Microtus ochrogaster* that is not buff-bellied. In all pelages it is clear, silvery white or gray on the under surface, and in dorsal coloration is the darkest of all the races. Unlike other forms it does not show a pepper-and-salt pelage, as the light-colored hairs on the back are darker and reduced in number. In coloration it so closely resembles *Microtus pennsylvanicus* that collectors who are not sensitive to the coarseness of fur of *Microtus ochrogaster* will likely overlook this animal. It has, of course, a much shorter tail than any *M. pennsylvanicus*, and a glance at its dentition will speedily reveal its true identity. Unfortunately, examination of the plantar tubercles will not, since the local stock of *M. pennsylvanicus* is sometimes five-tubercled. It is a larger animal than typical *Microtus ochrogaster*, averaging nearly 10 millimeters longer. It also has a shorter foot, with a smaller, broader skull, and much reduced teeth.

Specimens examined.—

INDIANA.—Salamonia, Jay Co., 6 (Field Museum coll.).

OHIO.—Smoky Creek, Adams Co., 3; Ripley, Brown Co., 1; Symmes Creek, 1½ miles north of Chesapeake, Lawrence Co., 5 (including type); Union Township, Scioto Co., 4 (Ohio Coop. Wildlife Res. Sta. coll.); Shelby Co., 3 (Ohio State Museum; the specimens first reported for Ohio by Henninger, Journ. Mamm., Vol. II, 1921, p. 239).

Microtus ochrogaster ochrogaster (Wagner)

MIDDLE WESTERN PRAIRIE VOLE

Hypudaeus ochrogaster WAGNER, in Schreber's Säugthiere, Suppl., Vol. III, 1842, p. 592.

Type Locality.—America; hereby fixed at New Harmony, Posey County, Indiana.

At New Harmony, Indiana, *Microtus ochrogaster* appears in its most buff-bellied stock. This also happens to be a spot known to have been visited by the Prince of Wied in the course of his travels in America, and is very likely the source of the specimens that he obtained, and that furnished the basis for Wagner's description. The cranial measurements of 1 of these specimens, as given by Wagner[1], agree with the averages obtained from a series taken at New Harmony.

Specimens of the prairie vole from Hamilton and Clermont counties, Ohio, although strongly variable in all characters, are prevailingly buff bellied, and are paler backed than from elsewhere in the State. Except for one particular, they are clearly intermediate between *Microtus o. ohionensis*, described above, and topotypical *Microtus ochrogaster*, but are closer to the latter. This one particular, however, is of great interest.

The posterior loop of m_3 in the upper jaw of all examples of the subgenus *Pedomys* that the writers have seen is strongly hooked. In most specimens from the Cincinnati region, the hook is poorly developed or absent, and the posterior loop forms a symmetrical pattern very different from that of other stocks. The tooth pattern of *Arvicola cinnamonea* Baird, as pictured by him[2] can be closely matched by many of these specimens. Concerning the type of *Arvicola cinnamonea* Bailey says[3]: "Except for a slightly abnormal tooth pattern Baird's type of *cinnamonea* is a large specimen of typical *austerus*. I cannot believe that it ever came from Pembina." The writers have not examined Baird's type, and have not had the time to study enough specimens to be able to decide whether or not these Cincinnati specimens should stand as *Microtus ochrogaster cinnamoneus* (Baird). They currently believe that pending further study the typical race should be retained on the Ohio State list.

[1]See Osgood, Proc. Biol. Soc. Wash., Vol. XX, April 18, 1907, p. 48.
[2]Rep. Explor. and Surv. R. R. Pac., Vol. VIII, 1857, pl. LIV, No. 1714.
[3]North Amer. Fauna, No. 17, June 6, 1900, p. 74.

As in the case of the genus *Blarina*, it was impossible to work out the ranges of the Ohio races of the species under present consideration without assembling material from all over its range. With specimens sent on loan by the United States Biological Surveys, the Cincinnati Society of Natural History, The Ohio State Museum, The Ohio Wildlife Experiment Station, and the Field Museum of Natural History; others received in exchange from the Kansas University Museum of Zoology; and material already at hand in the Cleveland Museum of Natural History, it becomes possible to make a preliminary revision of the meadow voles of the subgenus *Pedomys* Baird. From the material at hand, it appears that most of the names so far applied to forms of the subgenus *Pedomys* are valid, and that these forms should stand as subspecies of *Microtus ochrogaster* (Wagner), with the exception of *Microtus ludovicianus* Bailey, which is geographically far removed from the others and shows distinctive cranial characters, thus appearing to be a distinct species. The forms may be defined thus:

1.—*Microtus ochrogaster ochrogaster* (Wagner). Middle Western Prairie Vole

Hypudaeus ochrogaster Wagner, in Schreber's Säugthiere, Suppl., Vol. III, 1842, p. 592.

Arvicola austerus LeConte, Proc. Acad. Nat. Sci. Phila., Vol. VI, 1853, p. 405 (type from Racine, Wisconsin).

Arvicola (*Pedomys*) *cinnamonea* Baird, Rep. Explor. and Surv. R. R. Pac., Vol. VIII, 1857, p. 543 (type supposed to have come from Pembina, North Dakota).

Type Locality.—New Harmony, Posey County, Indiana.

Range.—From extreme southwestern Ohio, southeastern Indiana, and northwestern Kentucky; west over Illinois to western Iowa and eastern Kansas.

Diagnosis.—Dark colored with very buffy under parts and very grizzled upper parts; skull of median proportions.

Specimens examined:

Illinois.—Olive Branch, Alexander Co., 21 (20 in Field Museum, 1 in U. S. Biological Surveys coll.); McClure, Alexander Co., 1 (U. S. Biological Surveys coll.); Rosiclare, Hardin Co., 15 (Field Museum); Galena, Jo Davies Co., 2 (Field Museum); Ozark, Johnson Co., 2 (Field Museum); Reevesville,

Johnson Co., 2 (Field Museum); Beach, Lake Co., 1 (Field Museum); Fox Lake, Lake Co., 6 (Field Museum); Odin, Marion Co., 1 (U. S. Biological Surveys coll.); Bloomington, McLean Co., 9; Golconda, Pope Co., 6 (Field Museum); Olney, Richland Co., 1 (U. S. Biological Surveys coll.); Wolflake, Union Co., 1 (U. S. Biological Surveys coll.); Wheatland, Will Co., 2 (Field Museum).

INDIANA.—Vincennes, Knox Co., 1 (U. S. Biological Surveys coll.); La Porte, La Porte Co., 2 (Field Museum); New Harmony, Posey Co., 16.

IOWA.—Knoxville, Marion Co., 3 (*haydenii-ochrogaster* intergrades; Field Museum); Fairport, Muscatine Co., 3 (*haydenii-ochrogaster* intergrades; U. S. Biological Surveys coll.).

KANSAS.—Lawrence, Douglas Co., 4 (*haydenii-ochrogaster* intergrades; Field Museum); Douglas Co. (no further locality), 5 (*haydenii-ochrogaster* intergrades).

MINNESOTA.—Hokah, Houston Co., 1 (*minor-ochrogaster* intergrades; Field Museum).

NEBRASKA.—Blair, Washington Co., 9.

OHIO.—Union Township, Clermont Co., 37 (22 in Cincinnati Soc. Nat. Hist.); Hamilton Co. (no further locality), 31 (22 in Cincinnati Soc. Nat. Hist.).

WISCONSIN.—Racine, Racine Co., 4 (U. S. Biological Surveys coll.).

2.—*Microtus ochrogaster ohionensis* Bole and Moulthrop. OHIO PRAIRIE VOLE

Microtus ochrogaster ohionensis BOLE and MOULTHROP, Scient. Pub. Cleveland Mus. Nat. Hist., Vol. V, No. 6, September, 1942, p. 155.

Type Locality.—Symmes Creek, 2 miles north of Chesapeake, Lawrence County, Ohio.

Range.—Occupies the northeastern border of the range of the species south of the Great Lakes, in a belt of unknown width extending from Jay County, Indiana, southeastward through Shelby County, Ohio, to the Ohio Valley counties of extreme central southern Ohio.

Diagnosis.—As described above, the only white-bellied race of the group, with slightly mixed very dark upper parts.

3.—*Microtus ochrogaster haydenii* (Baird). WESTERN PRAIRIE VOLE

Arvicola (*Pedomys*) *haydenii* BAIRD, Rep. Explor. and Surv. R. R. Pac., Vol. VIII, 1857, after July 20, p. 543.

Type Locality.—Fort Pierre, Stanley County, South Dakota.

Range.—South Dakota, south to Nebraska and western Kansas; and west to eastern Colorado, eastern Wyoming, and southeastern Montana.

Diagnosis.—Large and very pale; with a huge skull, grayish, grizzled upper parts, and very pale buff under surface.

Specimens examined.—

NEBRASKA.—Southeast of Wood Lake, Cherry Co., 2 (Field Museum).

SOUTH DAKOTA.—Elk Mountain, Custer Co., 1; Interior, Jackson Co., 4.

4.—*Microtus ochrogaster minor* (Merriam). LEAST PRAIRIE VOLE

Arvicola austerus minor MERRIAM, Amer. Nat., Vol. XXII, No. 7, July, 1888, p. 600.

Type Locality.—Bottineau, at base of Turtle Mountains, Bottineau County, North Dakota.

Range.—Northwestern Minnesota and northern North Dakota to central Alberta, occupying the northern edge of the range of the species.

Diagnosis.—Similar to *Microtus ochrogaster haydenii* in dorsal coloration, but even more grizzled; more buffy below, and with a very much smaller skull; also in every way a much smaller animal.

Specimens examined.—

ALBERTA.—Red Deer River, 9 (Field Museum).

SASKATCHEWAN.—Dundurn, Hanley Co., 1; Indian Head, Qu' Appelle Co., 2 (U. S. Biological Surveys coll.).

MINNESOTA.—Fort Snelling, Hennepin Co., 3 (Field Museum).

NORTH DAKOTA.—Minnewaukan, Benson Co., 1 (Field Museum); Oakes, Dickey Co., 1 (U. S. Biological Surveys coll.); Goodall, McKenzie Co., 1 (U. S. Biological Surveys coll.); Stump Lake, Nelson Co., 1 (U. S. Biological Surveys coll.); Jamestown, Stutsman Co., 2 (Field Museum coll.); Kenmore, Ward Co., 1 (U. S. Biological Surveys Coll.); Minot, Ward Co., 2 (Field Museum).

5.—*Microtus ludovicianus* Bailey. LOUISIANA PRAIRIE VOLE

Microtus ludovicianus BAILEY, North Amer. Fauna, No. 17, June 6, 1900, p. 74.

Type Locality.—Iowa, Calcasieu Parish, Louisiana.

Range.—The coastal prairie of southwestern Louisiana.

Diagnosis.—A dark, richly colored form of *Pedomys,* characterized by its greatly elongated, narrowed skull; the pinkish cast of

the upper parts is very outstanding, as are numerous cranial characters such as the great size of the molar teeth, distinctive molar pattern, dark color of the incisors, and flattened dorsal outline of the cranium. This vole well merits specific separation from *Microtus ochrogaster* in view of its divergent characters, the isolated position of its range, and the lack of evidence of intergradation.

Specimens examined.—

LOUISIANA.—Iowa, Calcasieu Parish, 6 (topotypes; U. S. Biological Surveys coll.).

Pitymys pinetorum pinetorum (LeConte)

SOUTHEASTERN PINE VOLE

Psammomys pinetorum LECONTE, Ann. Lyceum Nat. Hist. N. Y., Vol. III, 1830, p. 133.

Type Locality.—Pine forests of Georgia. Probably the old LeConte plantation at Riceboro[1].

Most of the pine voles in the Cleveland Museum of Natural History collection (150 specimens) are at present in the United States National Museum awaiting a revision of the genus by Remington Kellogg. However, 4 specimens at hand from Belmont County in southeastern Ohio seem, on the basis of Bailey's description[1], to be referable to *Pitymys p. pinetorum*, the Atlantic coast race.

Specimens examined.—

NORTH CAROLINA.—Currituck, Currituck Co., 17; Marshall, Madison Co., 9.

OHIO.—Cat Run, Belmont Co., 19.

Pitymys pinetorum scalopsoides (Audubon and Bachman)

NORTHEASTERN PINE VOLE

Arvicola scalopsoides AUDUBON AND BACHMAN, Proc. Acad. Nat. Sci. Phila., Vol. I, 1841, p. 97.

Type Locality.—Long Island, New York.

Pine voles from northeastern and central Ohio have by the senior author[2] previously been referred to *Pitymys pinetorum*

[1]See Bailey, North Amer. Fauna, No. 17, June 6, 1900, p. 63.
[2]Bole, Journ. Mamm., Vol. XIX, No. 3, August 18, 1938, p. 377.

scalopsoides. The available pine voles in this museum's collection show a very close color resemblance to a series of 7 topotypes from Long Island (Wading River, Suffolk County), New York. Although the remaining skulls at hand are not of comparable age, the northeastern Ohio skulls appear to be smaller and more lightly built than those of the topotypical series. The average external measurements of a series of 9 adults from the Holden Arboretum, Lake County, Ohio, are smaller than the same measurements in the topotypical series, and are as follows, with also the average of 7 topotypes in parentheses: total length, 118.9 (130.1); tail, 18.8 (20.9); hind foot, 15.4 (16.7). Intergradation with *Pitymys p. auricularis* occurs in south central Ohio[1].

Specimens examined.—

New Jersey.—Mays Landing, Atlantic Co., 4.

New York.—Wading River, Suffolk Co., 7 (topotypes).

Ohio.—Mechanicsville, Ashtabula Co., 1; Clinton Co., 1 (Ohio State Museum); Brecksville, Cuyahoga Co., 1; Chagrin Falls, Cuyahoga Co., 1; Gates Mills, Cuyahoga Co., 7; North Chagrin Metropolitan Park, 21; Bern Township, Fairfield Co., 14 (Ohio State Museum); Chesterland Caves, Geauga Co., 2; Little Mountain, Geauga Co., 29; Thompson Township, Geauga Co., 12; Neotoma, Hocking Co., 1 (Ohio State Museum); Holden Arboretum, Lake Co., 26; Kirtland, Lake Co., 3; London, Madison Co., 4 (Ohio State Museum).

Pitymys pinetorum auricularis (Bailey)

Bluegrass Pine Vole

Microtus pinetorum auricularis Bailey, Proc. Biol. Soc. Wash., Vol. XII, April 30, 1898, p. 90.

Type Locality.—Washington, Adams County, Mississippi.

Pine voles from extreme southern Ohio are referable to this dark, richly colored southern race[1]. Average measurements of a series of 8 adults from Clermont County, Ohio, are as follows: length, 126.4 mm.; tail, 23.3; hind foot, 16.1.

A series of autumn, winter, and spring specimens from Clermont County shows a very dark, glossy winter pelage. Judging from these examples this winter pelage is of extremely short duration, appearing in late December and disappearing in early March.

Specimens examined.—

Indiana.—New Harmony, Posey Co., 2.

[1]See Bole, loc. cit.

Ohio.—Lynx Prairie, Adams Co., 1 (Ohio State Museum); Smoky Creek, Adams Co., 8; Ripley, Brown Co., 4; Union Township, Clermont Co., 10 (1 in Ohio State Museum); Symmes Creek, Lawrence Co., 1.

Tennessee.—Jefferson Co. (no further locality), 2.

Ondatra zibethica zibethica (Linnaeus)

Common Muskrat

[*Castor*] *zibethicus* Linnaeus, Syst. Nat., ed. 12, Vol. I, 1766, p. 79.

Type Locality.—Eastern Canada.

The muskrat is a common animal in Ohio, wherever it can find aquatic habitats suitable to its needs. Ohio-caught specimens are not separable from those taken in other parts of the northeastern United States.

An interesting series of cranial variations is provided by skulls of early post-glacial age recovered from peat bogs, notably that at Johnstown, Ohio, from which was obtained the splendid mastodon now on exhibition in the Cleveland Museum of Natural History. In general these muskrat skulls are more robustly built than are those from present-day specimens, are considerably larger, and cannot be referred to the subspecies *Ondatra zibethica zibethica.*

Ohio specimens examined.—

Cuyahoga County.—Brooklyn, 1; Cleveland, 2; Pepper Pike, 1.

Lake County.—Holden Arboretum, 9; Kirtland Hills, 22; Mentor, 1.

Portage County.—Aurora Pond, 1; Freedom Station, 1.

Ottawa County.—Sandusky Bay, 1; Winous Point, 4.

Rattus norvegicus (Erxleben)

Norway Rat

[*Mus*] *norvegicus* Erxleben, Syst. Regni Anim., Vol. I, 1777, p. 381.

The Norway, or barn, rat is all too common near the habitations of the white man throughout Ohio. This introduced species is without doubt the least interesting, from a taxonomic point of view, of any of Ohio's mammals.

Ohio specimens examined.—

Adams County.—Smoky Creek, 2.

CUYAHOGA COUNTY.—Cleveland, 4; Cleveland Heights, 1; Gates Mills, 3; Independence, 1; Lakewood, 1; Lyndhurst, 3; North Chagrin Metropolitan Park, 1; Rocky River Metropolitan Park, 1.

LAKE COUNTY.—Kirtland Hills, 1.

ROSS COUNTY.—Bainbridge, 1.

SENECA COUNTY.—Bettsville, 6.

Rattus rattus rattus Linnaeus

BLACK RAT

[*Mus*] *rattus* LINNAEUS, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 61.

Type Locality.—Upsala, Sweden.

The Cleveland Museum of Natural History's only specimens of Ohio-caught black rats were destroyed in the fire already mentioned[1]. The species was listed by Kirtland[2], and it was apparently rather common soon after the country was settled, but subsequently died out. It is very rare if not wholly extinct in Ohio today.

Mus musculus musculus Linnaeus

COMMON HOUSE MOUSE

[*Mus*] *musculus* LINNAEUS, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 62.

Type Locality.—Upsala, Sweden.

The house mouse is thoroughly established as a wild species throughout Ohio. Outside of cities, it shows a strong preference for damp grassland habitats, and is especially fond of sedge meadows. Northern Ohio house mice are typical *Mus musculus musculus* and are prevailingly dark bellied (almost always so in wild-caught specimens).

Ohio specimens examined.—

ASHTABULA COUNTY.—Mechanicsville, 1; Padanaram, 1.

BELMONT COUNTY.—Cat Run, 5.

COLUMBIANA COUNTY.—Lisbon, 3.

CUYAHOGA COUNTY.—Bedford, 2; Chagrin Falls, 4; Cleveland, 12; Cleveland Heights, 3; Gates Mills, 4; Independence, 1; Lakewood, 4; Lyndhurst, 7; Rocky River Metropolitan Park, 1.

GEAUGA COUNTY.—Chesterland, 2; Lake Punderson, 1; Little Mountain, 4; Parkman, 1.

[1]Antea, p. 120.
[2]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 161.

Hancock County.—Fostoria, 2.

Lake County.—Holden Arboretum, 8; Madison Township, 2; Mentor, 6; Mentor Harbor, 1; Richmond Beach, 3.

Lorain County.—Avon Lake, 1.

Ottawa County.—Bay Point, 4.

Paulding County.—Payne, 1.

Portage County.—Aurora Pond, 10.

Sandusky County.—Burgoon, 3.

Seneca County.—Bettsville, 26; Cromers, 3; Feaselburg, 1; Liberty Township, 1; Maple Grove, 3; Old Fort, 2.

Summit County.—Peninsula, 1.

Wood County.—Longley, 1.

Mus musculus brevirostris Waterhouse

Southern House Mouse

[*Mus*] *brevirostris* Waterhouse, Proc. Zool. Soc. London, Part V, November 21, 1837, p. 19.

Type Locality.—Maldonado, Uruguay[1].

Moulthrop has shown[2] that the house mouse of extreme southern Ohio and of the southern United States in general should be recognized as *Mus musculus brevirostris*, the common house mouse of southern Europe and northern Morocco, of which *Mus musculus azoricus* Schinz is a synonym. House mice from the Ohio River counties of the State are prevailingly white bellied, and are somewhat lighter colored above than the larger specimens from the northern part of Ohio. Intergradation is shown in examples from a wide belt across the southern half of the State.

Ohio Specimens examined.—

Adams County.—Smoky Creek, 14.

Lawrence County.—Symmes Creek, 1.

Zapus hudsonius hardyi Batchelder

New England Jumping Mouse

Zapus hudsonius hardyi Batchelder, Proc. New Eng. Zoöl. Club, Vol. I, February 8, 1899, p. 5.

Type Locality.—Mt. Desert Island, Maine.

In the present unrevised condition of the genus *Zapus* it is quite impossible to draw any completely satisfactory conclusions

[1]See Cabrera, Trab. Mus. Nac. de Cienc. Nat. Madrid, Zool. Ser. No. 57, December 30, 1932, p. 255.

[2]Scient. Publ. Cleve. Mus. Nat. Hist., Vol. V, No. 5, June 1, 1942, pp. 80-81.

regarding the status of *Zapus hudsonius* in Ohio. Edward A. Preble, author of the most recent revision[1], was extremely conservative in his treatment of the species, so much so, that the true range of variation cannot be appreciated from a study of the distribution that he gives[2]. Mr. Preble had for examination only alcoholic material from Hudson Bay, the type locality of *Zapus hudsonius*. So far as topotypes are concerned, the writers are in the same position as Mr. Preble, since they have seen no fresh topotypes. In the Cleveland Museum of Natural History, however, there are specimens enough to show that the range of *Zapus hudsonius hudsonius*, as conceived by Preble, embraces at least 8 currently unrecognized forms. Preble was extremely brief in his treatment of *Zapus hudsonius hardyi* Batchelder; but this form is, in the opinion of the authors, absolutely valid, and is applicable to the bright-flanked, dark-backed *Zapus* that ranges from coastal Maine and central New Hampshire through southern New England, New York, and northwestern Pennsylvania into northeastern Ohio. This decision is arrived at on the assumption that specimens from the upper peninsula of Michigan, from Lake Simcoe, Ontario, and Lake Nipigon, Ontario, represent typical *Zapus hudsonius*, an assumption fraught with some danger, as there is considerable difference in series from these 3 regions. Specimens in *fresh summer pelage* from the range of *Z. h. hardyi* as given above are distinguishable at a glance from those in comparable pelage from Ontario, being much brighter on the sides, as well as darker on the back.

In northeastern Ohio *Zapus hudsonius hardyi* becomes extremely variable in all pelages, but there occur regularly specimens that in every respect match those from Massachusetts and Maine. Certain examples from Geauga County are much more blackish on the back than any from other parts of the race's range; while others are very dull colored, indicating approach to the subspecies from southeastern Ohio, hereinafter described as new. Still others are rich orange and show characters near *Zapus hudsonius brevipes* from the northwestern part of the State, also herein described as new, even to the extent of having shorter tails and feet. It seems best to treat specimens from northeastern Ohio as *Z. h. hardyi*, which they for the greater part most closely resemble. That there

[1]North Amer. Fauna, No. 15, August 8, 1899, pp. 1-42, pl. I.
[2]Loc. cit., p. 15.

is a local tendency toward the development of a new subspecies in Geauga County cannot be denied. Geauga specimens also seem to molt at a time different from other stocks of the present race. June specimens of *hardyi* from Massachusetts are in full molt; in northeastern Ohio the race molts in July, and individuals in fresh pelage are not available before August 1.

A series from Madison Township, Lake County, is very peculiar, and seems to show intergradation toward both *Zapus hudsonius brevipes* and typical *Z. h. hudsonius*. West of the Cuyahoga River, *Zapus* is found in ever increasing brightness of coloration as the range of *Z. h. brevipes* is approached. Most of the specimens at hand from Western Cuyahoga County are nearer *Z. h. brevipes* than to *Z. h. hardyi*.

Specimens examined.—

Zapus hudsonius hardyi

MAINE.—Small Point Beach, Sagadohoc Co., 1.

MASSACHUSETTS.—West Chop, Marthas Vineyard Island, Dukes Co., 1; Essex, Essex Co., 4; Plymouth, Plymouth Co., 1; Raynham, Plymouth Co., 1; Wareham, Plymouth Co., 1.

NEW HAMPSHIRE.—Jackson, Carroll Co., 1; Pittsburg, Coos Co., 4.

NEW YORK.—Elba, Genesee Co., 2; Peterboro, Madison Co., 4.

OHIO.—Mechanicsville, Ashtabula Co., 3; Chagrin Falls, Cuyahoga Co., 6; Gates Mills, Cuyahoga Co., 3; Mayfield Village, Cuyahoga Co., 1; North Chagrin Metropolitan Park, Cuyahoga Co., 1; Auburn Corners, Geauga Co., 1; Carvers Pond, Geauga Co., 3; Great South Bog, Geauga Co., 9; Little Mountain, Geauga Co., 1; Munson Township, Geauga Co., 8; Novelty, Geauga Co., 1; Lake Punderson, Geauga Co., 4; Parkman, Geauga Co., 1; Shady Lake, Geauga Co., 2; Holden Arboretum, Lake Co., 21; Indian Point, Lake County, 1; Madison Township, Lake Co., 11; Mentor Marsh, Lake Co., 3; Wickliffe, Lake Co., 2; Aurora Pond, Portage Co., 15.

PENNSYLVANIA.—Pymatuning Lake, Crawford Co., 3.

Zapus hudsonius hudsonius

ONTARIO.—Aurora, York Co., 4; Nipigon, Thunder Bay, 3 (U. S. Biological Surveys coll.).

MICHIGAN.—Newberry, Luce Co., 10.

Zapus hudsonius campestris

SOUTH DAKOTA.—Bull Springs, Custer Co., 10.

Zapus hudsonius americanus

NEW JERSEY.—Mays Landing, Atlantic Co., 3.

Zapus hudsonius brevipes, subsp. nov.

Short-footed Jumping Mouse

Type.—Adult female, skin and skull, No. 13797, Cleveland Museum of Natural History; November 5, 1938; Winston C. Jesseman.

Type Locality.—Bettsville, Seneca County, Ohio.

Range.—Northwestern Ohio, also probably most of Indiana and the lower peninsula of Michigan.

Diagnosis.—A brightly colored jumping mouse with a distinct dorsal band which is heavily suffused with the color of the flanks; with shorter hind feet and a shorter tail than found in *Zapus hudsonius hardyi* or *Zapus hudsonius hudsonius;* much more richly colored than *Zapus hudsonius campestris.*

Color.—Fresh winter pelage (the type). Upper parts with darkened dorsal band, not much darker than the sides, but well-defined; general color of sides, crown, and back, ochraceous buff, the dorsal band heavily sprinkled with black hairs, the sides lightly so; lateral line clear ochraceous buff, the hairs clear white at their bases; underfur of upper parts slate color; ears black on outer surfaces, bright ochraceous buff on margins and inner surfaces; nose somewhat more blackish than rest of upper parts; lower parts white, lightly suffused with ochraceous buff in a band across chest and between forelegs; feet silvery white above, naked below; hocks black; tail slaty gray above, clear white below. *Fresh summer pelage* (No. 15665, C. M. N. H., July 14, a paratype). Much brighter and more richly colored than the type, more orange tinged throughout; sides light ochraceous orange; dorsal band very distinct and heavily suffused with the color of the flanks; a spot of bright ochraceous buff over each eye; ears as in winter pelage, but the inner surfaces more blackened; a faint buffy chest band present.

Skull.—Similar to that of examples of *Zapus hudsonius hardyi* from New England or of *Zapus h. hudsonius* from Ontario, but narrower.

Measurements.—Type: length, 205 mm.; tail, 113; hind foot, 28; greatest length of skull (occipitonasal), 21.6; condylobasilar length, 17.8; zygomatic breadth, 10.6; mastoid breadth, 9.7; interorbital constriction, 4.3; palatal length (incisors to notch), 8.0;

postpalatal length (notch to anterior border of foramen magnum), 8.5; tooth row, 3.5; fronto-palatal depth at m_2, 7.5.

Remarks.—This is a well defined race not very closely related to other neighboring subspecies. It differs from typical *Zapus hudsonius hardyi* from Massachusetts and Maine in having a shorter tail, much shorter foot, and more yellowish back; its skull is narrower but otherwise similar. It differs still more sharply from examples of *Zapus h. hardyi* from northeastern Ohio, which are in many cases very much more blackish on the back than specimens from Maine. Actually, the color of *Zapus h. brevipes* is almost identical with the otherwise very distinct *Zapus trinotatus trinotatus* from the northwestern coast of the United States. Compared to typical *Zapus h. hudsonius* from Ontario or northern Michigan, *Z. h. brevipes* differs very strongly in color, smaller skull, shorter foot, and shorter tail. It is much more richly colored than *Zapus hudsonius campestris.*

A specimen from Waters, Otsego County, Michigan, is quite indistinguishable from the paratype series from Seneca County, Ohio, except for an anomalous patch of white behind one ear. This individual is radically different from examples of *Zapus* from Luce County, across the Straits of Mackinac, and it seems safe to infer that the range of *Z. h. brevipes* includes most, if not all, of the southern peninsula of Michigan.

Specimens examined.—

Michigan.—Waters, Otsego Co., 1.

Ohio.—Big Creek (Cleveland), Cuyahoga Co., 1 (near *hardyi*); Dover, Cuyahoga Co., 1; North Olmsted, Cuyahoga Co., 1 (near *hardyi*); Rocky River Metropolitan Park, Cuyahoga Co., 2 (near *hardyi*); Mill Hollow, Erie Co., 1; Bettsville, Seneca Co., 3 (including type); Cromers, Seneca Co., 1; Old Fort, Seneca Co., 5.

Zapus hudsonius rafinesquei[1], subsp. nov.

Rafinesque Jumping Mouse

Type.—Adult male, skin and skull, No. 13260, Cleveland Museum of Natural History; August 27, 1938; Scott R. Inkley.

Type Locality.—Cat Run, extreme southeastern Belmont County, Ohio.

[1]Named for Constantine S. Rafinesque, naturalist of the early nineteenth century.

Range.—The hill country of southeastern Ohio; also southwestern Indiana; presumably all the Ohio Valley as well.

Diagnosis.—A very distinctive race characterized by a combination of important cranial characters, small body, very long tail, and almost total lack of a dorsal band; similar to *Zapus hudsonius americanus* but paler; the only race of *Zapus hudsonius* without a distinct dorsal band.

Color.—Fresh summer pelage (the type). Upper parts, including sides and crown, light ochraceous buff, heavily sprinkled with long coarse black hairs; dorsal band almost obliterated; back slightly darker than sides; underfur of upper surface light slaty gray; lateral line pale ochraceous buff, broad and not distinctly separated from color of under parts, and widening as well as brightening on head, forming a conspicuous bright ochraceous buff patch on side of face below the eyes; nose colored like upper surface; lower parts white, faintly suffused with buff; feet silvery white; hocks light gray; tail gray above, clear white below; ears blackish on both surfaces, lightly sprinkled with buffy hairs; margins of ears light ochraceous buff.

Skull.—Of the general proportions of *Zapus hudsonius hudsonius*, but with a much shorter postpalatal length (nearly 1 mm.), longer tooth row, and the narrowest interorbital constriction of any race of the species.

Measurements.—Type: length, 208 mm.; tail, 130; hind foot, 28; greatest length (occipitonasal) of skull, 21.7; condylobasilar length, 18.5; zygomatic breadth, 11.3; mastoid breadth, 10.0; interorbital constriction, 3.9; palatal length (incisors to notch), 8.3; postpalatal length (notch to foramen magnum), 7.4; tooth row, 3.7; fronto-palatal depth at m_2, 7.2.

Remarks.—Rafinesque, erratic genius that he was, was never so erratic as when assigning names to jumping mice of the genus now known as *Zapus*. He supplied 8 names for supposed species of this genus, most of which stand as *nomina nuda* or synonyms today[1]. Several of these names are clearly referable to known forms, but unfortunately, those that are identifiable refer not to examples of *Zapus* but to species of some other genus. That his "*Gerbillus leonurus*" refers to some kind of *Dipodomys* can scarcely be doubted.

[1]See Preble, North Amer. Fauna, No. 15, August 8, 1899, pp. 10-13.

His description of "*Gerbillus megalops*" from the "pine barrens" of Kentucky can refer only to a juvenal *Peromyscus*. Rafinesque probably had a specimen of the animal now known as *Zapus princeps* in his hands when he applied the *nomen nudum* "*Gerbillus niger*" to it, since that species is the only *Zapus* that commonly occurs in melanistic pelage. It is equally probable that the race here described as *Zapus hudsonius rafinesquei* was the one that he had in mind when he named *Gerbillus sylvaticus*, without describing it or designating a type or type locality, in a letter to Samuel L. Mitchill at Louisville, Kentucky, dated July 20, 1818. As 2 specimens of *Zapus* in the Cleveland Museum of Natural History, from New Harmony, Indiana, are very much closer to the type of *rafinesquei* than they are to anything else, and as the race is thus known to inhabit country close to Louisville, it is reasonable to suppose that Rafinesque had this form in view.

This is a very distinct subspecies and is closest to *Zapus hudsonius americanus* (Barton), but is much paler than comparable specimens from the type region of that race, and differs in many other color details as well. It is quite unlike *Zapus hudsonius brevipes* from the plains of northwestern Ohio; but 1 of the 2 New Harmony, Indiana, specimens is suffused with orange in a way suggestive of *brevipes*, and both specimens are much shorter tailed than the type of *rafinesquei*. The dorsal bands of both are slightly more noticeable than in the type, indicating another approach to *Z. h. brevipes*. Intergradation with *Zapus hudsonius hardyi* is indicated by numerous examples of the latter race from its variable stock in northeastern Ohio.

It appears that *Zapus hudsonius rafinesquei* is a very rare animal, occupying as it does the southern border of the range of the species. Woodrow Goodpaster, despite the very thorough collecting that he did for the Cincinnati Society of Natural History in the Cincinnati region, does not list the species[1]; and the Cleveland Museum of Natural History's collectors have consistently failed to record it from Adams, Brown, and Lawrence counties at the southern tip of Ohio. Preble lists 1 specimen (as *Z. h. hudsonius*) from Wheeling, West Virginia[2], which is slightly north of the type locality of *Zapus h. refinesquei*. The present writers have not seen this specimen.

[1]Journ. Cinc. Soc. Nat. Hist., Vol. XXII, No. 3, June, 1941, pp. 41-47.
[2]Loc. cit., p. 17.

Specimens examined.—

INDIANA.—New Harmony, Posey Co., 2.
OHIO.—Cat Run, Belmont Co., 1 (type specimen).

Napaeozapus insignis insignis (Miller)

NORTHEASTERN WOODLAND JUMPING MOUSE

Zapus insignis MILLER, Amer. Nat., Vol. XXV, No. 8, August, 1891, p. 742.

Type Locality.—Restigouche River, New Brunswick.

Ohio specimens of the woodland jumping mouse are barely distinguishable from examples from New York and New Hampshire, and in the absence of topotypical material at the Cleveland Museum of Natural History it is inadvisable to do more than point out these divergent characteristics. On geographical grounds, it would seem very likely that the Ohio *Napaeozapus* should be subspecifically different from the form found in New England and New Brunswick. The average measurements of 33 Ohio adults are: length, 212 mm.; tail, 129; hind foot, 29; weight, 16.07 grams; of 6 from St. Huberts, Essex County, New York: length, 232; tail, 141.7; hind foot, 30.5; weight, 20.3 grams; of 16 from central New Hampshire: length, 226.3; tail, 139; hind foot, 30.9. These demonstrate that the Ohio animal is considerably smaller in series, but isolated individuals are as large as any from farther northeast. There is not the slightest difference in color, and only one cranial variation of note. In adults of the New England form the interpterygoid fossa terminates anteriorly in a plane bisecting the third molar, or even farther forward. In most of the Ohio specimens, the anterior border of the fossa is behind the third molar, but in several it is as far forward as in the northeastern specimens.

Woodland jumping mice are fairly common on the drainage of the Chagrin River in Lake and Geauga counties. In the ravines and gorges of this region the species finds a congenial environment in forests of hemlock and yellow birch, and frequents also rich beech-maple woodlands. The Chagrin River colony is apparently isolated, as not a specimen has as yet been taken in eastern Ashtabula County, despite trapping in suitable habitats. A single example is at hand from Cat Run, Belmont County, and is peculiar in having no white on the tail. As this station is the type locality of

Zapus hudsonius rafinesquei this specimen received special study. The lack of white, however, may indicate intergradation with *Napaeozapus insignis roanensis* (Preble), which in some individuals shows this character.

Specimens examined.—

New Hampshire.—Jackson, Carroll Co., 10; Jaffrey, Cheshire Co., 2; Pittsburg, Coos Co., 2; Mt. Moosilauke, Grafton Co., 1.

New York.—St. Huberts, Essex Co., 7.

Ohio.—Mechanicsville, Ashtabula Co., 1; Cat Run, Belmont Co., 1; Gates Mills, Cuyahoga Co., 1; North Chagrin Metropolitan Park, Cuyahoga Co., 3; Carvers Pond, Geauga Co., 1; Chester, Geauga Co., 1; Chesterland Caves, Geauga Co., 1; Lake Punderson, Geauga Co., 1; Little Mountain, Geauga Co., 3; Shady Lake, Geauga Co., 9; Holden Arboretum, Lake Co., 16; Kirtland Hills, Lake Co., 1; Willoughby Township, Lake Co., 1.

Erithizon dorsatum dorsatum (Linnaeus)

Canada Porcupine

[*Hystrix*] *dorsata* Linnaeus, Syst. Nat., ed. 10, Vol. I, January 1, 1758, p. 57.

Type Locality.—Eastern Canada.

Porcupines were once common in northeastern and northwestern Ohio and are still of sporadic occurrence along the Pennsylvania boundary. The Cleveland Museum of Natural History failed to secure a specimen run over by a car a few miles east of Cleveland, near the Chagrin River, in 1931. This museum formerly owned a specimen taken about 1830 in Lucas County. This specimen, which was part of the collections of the Cleveland Museum of Natural History's antecedent organizations, was burned in the manner already described[1].

Ohio specimens examined.—

Ohio.—(No further locality), 1.

Lucas County.—(No further locality), 1.

Lepus americanus virginianus Harlan

Northeastern Varying Hare

Lepus virginianus Harlan, Fauna Americana, 1825, p. 196.

Type Locality.—Blue Mountains, northeast of Harrisburg, Pennsylvania.

[1]Antea, p. 120.

The Cleveland Museum of Natural History's varying hares from Ohio suffered the same dismal fate as its porcupine. There were several in the Cleveland Academy of Science collection received from Case School of Applied Science. All were from Ashtabula County, in so far as data were provided. The species was first reported for Ohio by Dr. J. P. Kirtland, who says it ". . . . is sometimes seen in the northeastern part of our limits".[1] The species is still to be expected in Ashtabula County. Regarding its distribution in that county, S. V. Wharram says: "I have not seen a snowshoe rabbit in this part of the State for many years. Many winters ago a boy about 15 years of age brought 1 to me to be mounted. He shot it in Harpersfield Township . . . . . I also saw 1 near Cat Swamp in Austinburg Township. Again I saw 1 in each of the townships of Monroe and Pierpont . . . .".

Ohio specimens examined.—

Ashtabula County.—(No further locality), 5 (all destroyed).

Sylvilagus floridanus mearnsii (J. A. Allen)

Middle Western Cottontail

Lepus sylvaticus mearnsii Allen, Bull. Amer. Mus. Nat. Hist., Vol. VI, Art. 6, May 31, 1894, p. 171.

Type Locality.—Fort Snelling, Hennepin County, Minnesota.

Cottontail rabbits occur in all parts of Ohio, and where divergent stocks are found these generally prove to be the result of hybridization between various non-native stocks. The State Division of Conservation has from time to time introduced cottontails from Missouri and Kansas into various parts of Ohio. These animals are presumably referable to *Sylvilagus floridanus alacer* (Bangs). Certain stocks of *S. f. mearnsii* from western Ohio, particularly those from Seneca County, show characters approaching *S. f. alacer*. It is highly probable that these tendencies indicate a result of hybridization rather than a local racial variance.

A still more interesting hybridization, consisting of an intergeneric cross, has made itself evident in city-surrounded Bratenahl, a suburb of Cleveland, in northeastern Cuyahoga County. At this station, domestic rabbits of the breed 'Champagne d'Argent' were sometimes allowed to run at large in a field for several years

[1]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 177.

(1920-1928). Interbreeding with native *Sylvilagus* occurred, and strongly influenced the local native stocks. The Champagne d'Argent, a medium-sized gray rabbit whose juveniles are coal black until half grown, is presumably a derivative of *Oryctolagus cuniculus*, the common European rabbit. During the years following 1928, the wild rabbits of Bratenahl were noticeably larger and more grayish than normal, and coal black juveniles occasionally appeared until a few years ago. These differences have today almost entirely disappeared.

Ohio specimens examined.—

Clermont County.—Union Township, 2.

Cuyahoga County.—Beechwood, 1; Bratenahl, 1; Chagrin Falls, 3; Cleveland, 4; Cleveland Heights, 1; Lakewood, 1; Lyndhurst, 1; South Euclid, 1.

Geauga County.—Little Mountain, 1.

Highland County.—Hillsboro, 2.

Lake County.—Kirtland Hills, 2; Kirtland Township, 1; Mentor, 2.

Portage County.—Geauga Lake, 6.

Sandusky County.—Burgoon, 1.

Seneca County.—Bettsville, 1; Maple Grove, 1.

Cervus canadensis canadensis Erxleben

American Wapiti

[*Cervus elaphus*] *canadensis* Erxleben, Syst. Regni Anim., Vol. I, 1777, p. 305.

Type Locality.—Eastern Canada.

At the time of white settlement the wapiti was found in all parts of Ohio. It has been extinct in the State since about 1840, at which time the last animals were killed in Ashtabula County. Kirtland reports that it was "frequently met with" in that county until about 1832[1].

To judge from the frequency with which the bones of this animal are found today, the wapiti must have been very abundant since the close of the ice age. Bone finds are on hand from nearly all post-glacial horizons. The following counties are represented by the remains: Ottawa, Sandusky, Erie, Portage, Summit, Cuyahoga, and Geauga.

[1]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 177.

Odocoileus virginianus virginianus (Boddaert)

VIRGINIA WHITE-TAILED DEER

[*Cervus*] *virginianus* BODDAERT, Elenchus Animalium, Vol. I, 1784, p. 136.

Type Locality.—Virginia.

The white-tailed deer became extinct in Ohio about 1850, although it had been very rare for several decades before that. Sporadic records of occurrence in the southeastern counties continued until about 1870, and in northwestern Ohio until 1881. The far-sighted deer conservation policy of the State of Pennsylvania has, however, resulted in the emphatic reestablishment of the species in northeastern Ohio, while restocking carried out by the Ohio Division of Conservation has added it to many southern counties. By 1925 this deer had pushed westward to the Cleveland region; by 1930 records began to come in with increasing frequency; and by 1940 the species had become common over the entire northeastern portion of Ohio. In Geauga County increasing numbers of highway accidents involving deer have resulted in widespread posting of deer crossing signs; in the Chagrin River district it is not unusual to see groups of 5 to 10 individuals, and deer tracks are commonplace. Wharram reports it as "gathering" in Ashtabula County. The white-tailed deer may now be said almost completely to have reoccupied Ohio, although it is still a rarity in many western counties.

Deer appear in great abundance in Indian village and peat-bog remains, and are common in bone finds from all post-glacial horizons.

Ohio specimens examined.—

LAKE COUNTY.—Willoughby-on-the-lake, 1.

CUYAHOGA, ERIE, GEAUGA, LAKE, PORTAGE, SANDUSKY, and SUMMIT COUNTIES.—Skeletal remains.

[The authors have been unable to locate authentic records of the occurrence of the moose (*Alces americanus americanus*) during historic times in Ohio. The species has appeared in the State mammal lists issued by the Ohio State Museum in recent years, including 1 compiled in part by the senior author[1]. Neither Kirtland, who was very familiar with the early history of Ashta-

[1]See Thomas and Bole, Bull. Ohio State Mus., No. 1,1938, p. 2.

bula County, nor Brayton, who was familiar with Indiana and northwestern Ohio, records the species for the State. Trautman[1] failed to discover evidence of its presence at Buckeye Lake during historic times. The present writers feel that the species should be removed from the State list.]

Bison bison pennsylvanicus Shoemaker

EASTERN BISON

Bison americanus pennsylvanicus SHOEMAKER, A Pennsylvania Bison Hunt, 1915, p. 9.

The eastern bison was formerly abundant over most of Ohio, and particularly numerous in southern Ohio as well as along the shores of Lake Erie. Brayton[2] gives a full historical record of the history of the species in the State at the time of settlement. The last specimens ever reported for Ohio, according to Kirtland[3] were killed on the Sandy Fork of Symmes Creek, Gallia County, in 1800.

The Cleveland Museum of Natural History has a few skeletal remains of the bison from Cuyahoga and Summit counties.

[1]Ohio Journ. Sci., Vol. XXXIX, No. 3, May, 1939, pp. 133-143.
[2]Rep. Geol. Surv. Ohio, Vol. IV, 1882, pp. 62-73.
[3]Second Ann. Rep. Geol. Surv. Ohio, 1838, p. 177.

BIBLIOGRAPHY

The subjoined list of publications contains only those that have been consulted in the present connection, and is not intended as a complete bibliography of the mammals of Ohio. It should, however, prove useful to students of the State fauna.

Allen, Joel Asaph

1895. **Descriptions of New American Mammals.** Bulletin of the American Museum of Natural History, Vol. VII, Article 10, November 8, 1895, pp. 327-340.

1897. **Additional Notes on Costa Rican Mammals, with Descriptions of New Species.** Bulletin of the American Museum of Natural History, Vol. IX, Article 3, March 11, 1897, pp. 31-44, pl. I.

Bachman, John

1837. **Some Remarks on the Genus Sorex, with a Monograph of the North American Species.** Journal of the Academy of Natural Sciences of Philadelphia, Vol. VII, pp. 362-402, pls. XXIII-XXIV.

Bailey, Vernon Orlando

1900. **Revision of the Voles of the Genus Microtus.** North American Fauna, No. 17, June 6, 1900, pp. 1-79, pls. I-IV.

Baird, Spencer Fullerton

1857. **Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean, Vol. VIII; General Report upon the Zoology of Several Pacific Railroad Routes, Part I, Mammals;** 1857 (after July 20), pp. I-XLVIII, 1-757, pls. XVII-LX.

Bole, Benjamin Patterson, Jr.

1938. **The Pine Mouse of Southern Ohio.** Journal of Mammalogy, Vol. XIX, No. 3, August 18, 1938, p. 377.

1939. **The Quadrat Method of Studying Small Mammal Populations.** Scientific Publications of the Cleveland Museum of Natural History, Vol. V, No. 4, December 28, 1939, pp. 15-77.

Brayton, Alembert Winthrop

1882. **Report on the Mammals of Ohio.** Report of the Geological Survey of Ohio, Vol. IV, pp. 1-185.

Cabrera, Angel

1932. **Los Mamíferos de Marruecos.** Trabajos del Museo Nacional de Ciencias Naturales, Madrid, Ser.Zool., No. 57, December 30, 1932, pp. 1-361, pls. I-XII, 34 figs.

Duvernoy, G. L.

1842. **Notices pour Servir à la Monographie du Genre Musaraigne.** Magazin de Zoologie, d' Anatomie Comparée et de Paléontologie, Ser. 2, Vol. IV, pp. 1-48, pls. XXXVIII-LV.

Enders, Robert Kendall

1928. **Two New Records for Ohio.** Journal of Mammalogy, Vol. IX, No. 2, May 9, 1928, p. 155.

1930. **Some Factors Influencing the Distribution of Mammals in Ohio.** Occasional Papers of the University of Michigan Museum of Zoology, No. 212, April 23, 1930, pp. 1-27.

Goldman, Edward Alphonso

1937. **The Wolves of North America.** Journal of Mammalogy, Vol. XVIII, No. 1, February 14, 1937, pp. 37-45.

Goodpaster, Woodrow

1941. **Mammals of Southwestern Ohio.** The Journal of the Cincinnati Society of Natural History, Vol. XXII, No. 3, June, 1941, pp. 41-47.

Goslin, Robert

1933. **The Striped Spermophile in Fairfield County, Ohio.** Journal of Mammalogy, Vol. XIV, No. 4, November 13, 1933, p. 369.

Green, Morris Miller

1932. **An Unrecognized Shrew from New Jersey.** University of California Publications in Zoology, Vol. XXXVIII, No. 7, June 9, 1932, pp. 387-388.

Hall, Eugene Raymond

1936. **Mustelid Mammals from the Pleistocene of North America, with Systematic Notes on Some Recent Members of the Genera Mustela, Taxidea, and Mephitis.** Publication of the Carnegie Institution of Washington, No. 473, November 20, 1936, pp. 41-120, pls. I-V, 6 figs.

1937. **Mustela cicognanii, the Short-tailed Weasel, Incorrectly Ascribed to Ohio.** The American Midland Naturalist, Vol. XVIII, No. 2, March [February 23], 1937, p. 304.

Hine, James Stewart

1929. **Distribution of Ohio Mammals.** Proceedings of the Ohio Academy of Science, Vol. VIII, Part 6, August 15, 1929, pp. 260-268.

Henninger, Walther Friedrich

1921. **Two Mammals New to Ohio.** Journal of Mammalogy, Vol. II, No. 4, November 29, 1921, p. 239.

Howell, Alfred Brazier

1927. **Revision of the American Lemming Mice.** North American Fauna, No. 50, June 30, 1927, pp. I-II, 1-37, pls. I-II.

Howell, Arthur Holmes

1915. **Revision of the American Marmots.** North American Fauna, No. 37, April 7, 1915, pp. 1-80, pls. I-XV.

1929. **Revision of the American Chipmunks.** North American Fauna, No. 52, November, 1929, pp. 1-157, pls. I-X.

1932. **Notes on Range of the Eastern Chipmunk in Ohio, Indiana, and Quebec.** Journal of Mammalogy, Vol. XIII, No. 2, May 11, 1932, pp. 166-167.

1938. **Revision of the North American Ground Squirrels.** North American Fauna, No. 56, April [May 18], 1938, pp. 1-256, pls. I-XXXII.

Jackson, Hartley Harrad Thompson

1928. **A Taxonomic Review of the American Long-tailed Shrews.** North American Fauna, No. 51, July, 1928, pp. I-VI, 1-238, pls. I-XIII.

Kellogg, Remington

1939. **Annotated List of Tennessee Mammals.** Proceedings of the United States National Museum, Vol. LXXXVI, No. 3051, February 14, 1939, pp. 245-303.

Kirkpatrick, John

1874. **Minutes of a Meeting of the Cleveland Academy of Science for January 30, 1857.** Proceedings of the Cleveland Academy of Natural Science, pp. 126-129.

Kirtland, Jared Potter

1938. **Report on the Zoology of Ohio.** Second Annual Report, Geological Survey of Ohio, Vol. II, pp. 160-161, 175-177.

Lyon, Marcus Ward, Jr.

1936. **Mammals of Indiana.** The American Midland Naturalist, Vol. XVII, No. 1, January [February 27], 1936, pp. 1-384.

Merriam, Clinton Hart

1895. **Revision of the Shrews of the American Genera Blarina and Notiosorex.** North American Fauna, No. 10, December 31, 1895, pp. 1-34, pls. I-III.

Miller, Gerrit Smith, Jr.; and Allen, Glover Morrill

1928. **The American Bats of the Genera Myotis and Pisonyx.** Bulletin of the United States National Museum, No. 144, April 18, 1928, pp. I-VIII, 1-218, pl. I.

Moseley, Edwin Lincoln

1934. **Increase of Badgers in Northwestern Ohio.** Journal of Mammalogy, Vol. XV, No. 2, May 14, 1934, pp. 156-158.

Moulthrop, Philip Nelson

1938. **The Prairie White-footed Mouse in New York State.** Journal of Mammalogy, Vol. XIX, No. 4, November 14, 1938, p. 503.

1942. **Description of a New House Mouse from Cuba.** Scientific Publications of the Cleveland Museum of Natural History, Vol. V, No. 5, June 1, 1942, pp. 79-82.

Osgood, Wilfred Hudson

1907. **Some Unrecognized and Misapplied Names of American Mammals.** Proceedings of the Biological Society of Washington, Vol. XX, April 18, 1907, pp. 43-52.

Poole, Earl Lincoln

1937. **Pennsylvania Records of Sorex cinereus fontinalis.** Journal of Mammalogy, Vol. XVIII, No. 1, February 14, 1937, p. 96.

1940. **The Technical Name of the Allegheny Woodrat.** Journal of Mammalogy, Vol. XXI, No. 3, August 13, 1940, pp. 316-318.

Preble, Edward Alexander

1899. **Revision of the Jumping Mice of the Genus Zapus.** North American Fauna, No. 15, August 8, 1899, pp. 1-42, pl. I.

Preble, Norman Alexander

1942. **Notes on the Mammals of Morrow County, Ohio.** Journal of Mammalogy, Vol. XXIII, No. 1, February 14, 1942, pp. 82-86.

Ridgway, Robert

1912. **Color Standards and Color Nomenclature.** Washington, D. C. 1912 [January 12, 1913], pp. [1-4], i-iv, 1-44, frontispiece, pls. I-LIII.

Smith, Ronald Ward

1940. **The Land Mammals of Nova Scotia.** The American Midland Naturalist, Vol. XXIV, No. 1, July 31, 1940, pp. 213-241.

Thomas, Edward Sinclair; and Bole, Benjamin Patterson, Jr.

1938. **List of the Mammals of Ohio.** Bulletin of the Ohio State Museum, No. 1, February, 1938, pp. 1-2.

Trautman, Milton Bernhard

1939. **The Numerical Status of Some Mammals throughout Historic Time in the Vicinity of Buckeye Lake, Ohio.** The Ohio Journal of Science, Vol. XXXIX, No. 3, May, 1939, pp. 133-143.

Wharram, Samuel Verrell

1933. **Mammals of Ashtabula County.** (Manuscript in the library of the Cleveland Museum of Natural History.)

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